



National Soil Services Centre (NSSC)
Department of Agriculture (DoA)
Ministry of Agriculture & Forests (MoAF)

“Soil and Plant Diversity Study along Gasa-Lunana Transect in Bhutan”



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Report # SSU - 2011/5

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1. INTRODUCTION

Mountains are among the most fragile environments on Earth and are facing enormous pressure from various drivers of global change, including climate change. Under the influence of climate change, mountains are likely to experience wide ranging effects on the environment, natural resources including biodiversity, and socioeconomic conditions. Little is known in detail about the vulnerability of mountain ecosystems to climate change. Intuitively it seems plausible that these regions, where small changes in temperature can turn ice and snow to water, and where extreme slopes lead to rapid changes in climatic zones over small distances, will show marked impacts in terms of biodiversity, water availability, agriculture, and hazards, and that this will have an impact on general human well being. However, because of very fragile and poorly accessible landscapes with sparsely scattered settlements and poor infrastructure in the mountains, research and assessment are done least where it is actually needed the most. Therefore, in various forums, the need for scientific information from high altitude areas especially at the national and local levels was raised time and again.

Bhutan being a mountainous country, climate change impacts would be inevitable. However, Bhutan does not have any reliable baseline information to date to better understand the current situation and the likely impacts of climate change in the country. And without any reliable baseline information, it would be very challenging to monitor, mitigate and adapt to climate change impacts. Baseline information on soil resources particularly soil organic matter and plant diversity among others would be very useful for understanding and monitoring the climate change impacts in the country.

Having realized the need to have some baseline information to better understand the likely impacts of climate change and aid future studies in the field of environment in the country, an attempt has been made by the Department of Agriculture (DoA) to establish baseline information on soil resources and plant diversity by establishing permanent reference plots along the Gasa - Lunana transect. A team consisting of representatives from relevant agencies carried out the 20 day fieldtrip to establish permanent reference plots from 15th Sept 2010 to 5th Oct. 2010 with financial support from the GEF/UNDP funded MSP Project based at the National Soil Services Centre (NSSC), Semtokha.

2. ACKNOWLEDGEMENT

We would like to extend our heartfelt gratitude to the Ministry of Agriculture and Forests (MoAF) for its invaluable support in carrying out this study. We would also like to thank the GEF/UNDP funded Medium Sized Project (MSP) for providing the financial support.

3. AIMS & OBJECTIVE

The main aims and objective of this study was to:

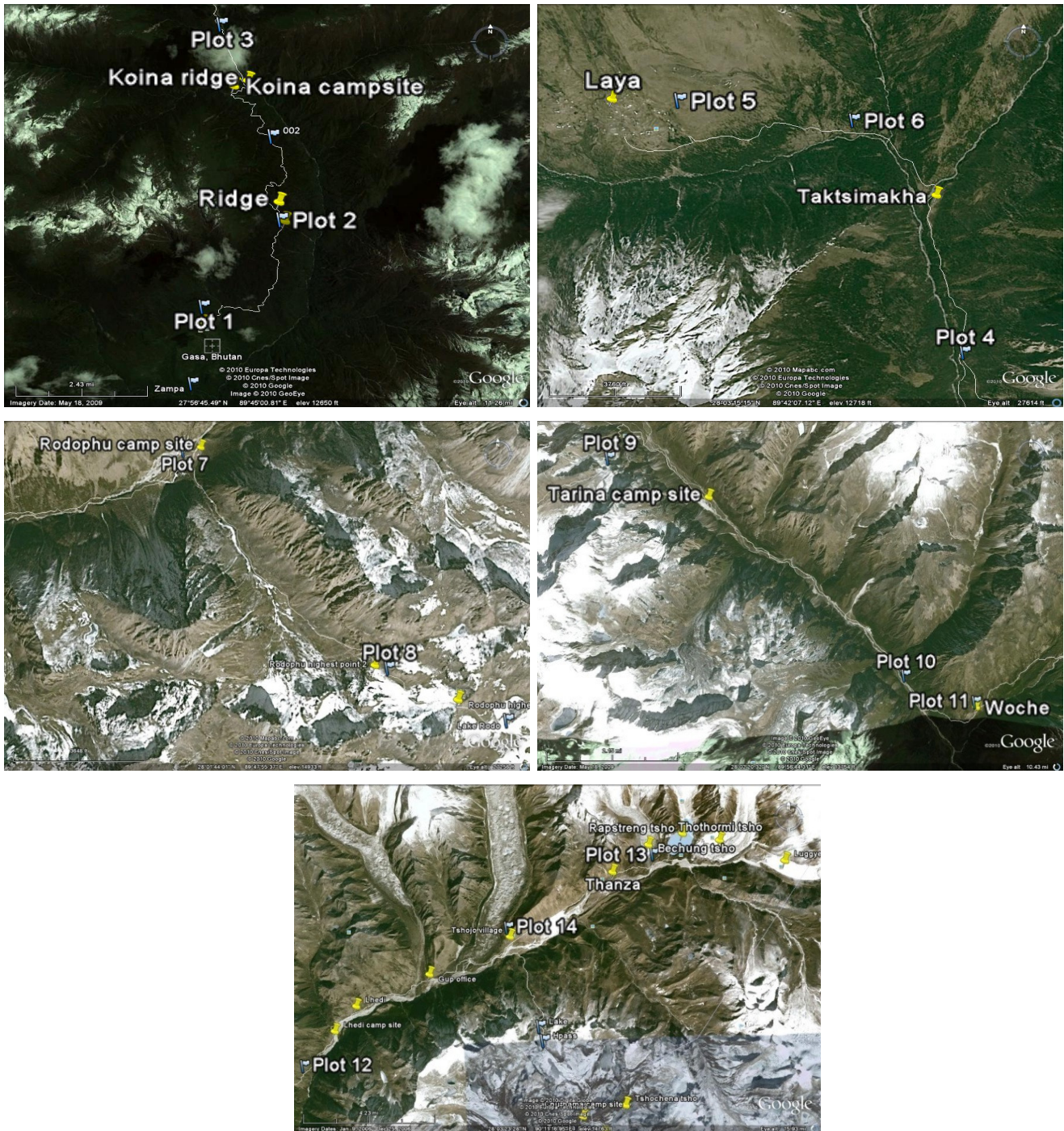
- Establish permanent reference plots along the Gasa – Lunana transect and collect soil and plant diversity information from these reference plots.
- Provide soil and plant diversity information for better understanding, monitoring and mitigating likely impacts of climate change and increased anthropogenic activities and
- Facilitate future studies in the field of environment in the country.

4. MATERIALS AND METHOD

4.1 Study area

The permanent reference plots were located along the Gasa - Lunana transect under Gasa Dzongkhag (Figures 1). The reference plots were established between 27° 54' 34.99" N to 28° 05' 51.49" N and 89° 43' 42.08" to 90° 14' 00" E.

Figure 1 Location of permanent reference plots



The study area (transect) stretches from an elevation of 2878m asl in Plot-1 above Gasa Dzong to about 4786m asl in Plot-8 below Thothormi Tsho in Lunana. It passes through different vegetation cover including mixed coniferous forest, coniferous forest, alpine scrubs and alpine meadows.

Geologically, the entire transect falls under Thimphu Formation with gneiss and granite (Fig. 6 & 7) as the dominant rock types. Singh (1996) has mapped the area between Laya and Masang Kang and recorded swarm of younger tourmaline granite dykes within the biotite granitoid gneissic terrain. This gneissic granite, with its variants, continues toward Lunana and further east.

There is no meteorological station at Laya and Lunana and the nearest meteorological station at Khatoe under Gasa was taken as the nearest equivalent. The annual rainfall is about 813mm and the highest rainfall was recorded in August with 183.40mm. The maximum temperature was recorded in July with 21°C and minimum recorded in January with -1.8°C. Since Laya and Lunana are located further in the north and with higher elevation than Khatoe, the annual rainfall would be less than 813mm. Likewise the maximum and minimum temperature would be also lower than Khatoe due to altitude and latitude effects.

4.2 Materials

During the study, the following materials were used:

- 1) Base map (Topo map, ALOS and Google images) for proper orientation and locating the permanent reference plots in the field.
- 2) GPS (Global Positioning System) instrument for finding the exact position of the permanent plots (through GPS coordinates) and its altitude above mean sea level
- 3) Compass for finding the slope gradient
- 4) Measuring tape to measure the reference plots
- 5) Soil Survey Equipment (1.2 m Edelman auger, soil colour charts, HCl, sampling bags, etc.) for soil auger description
- 6) Herbarium press and newspapers for collecting plant specimens
- 7) Soil auger and plant survey forms for recording the field information
- 8) Reference books (Flora of Bhutan (Vol. 1-3), Concise Flowers of the Himalayas, Flowers of the Himalayas–A Supplement, the Photo Guide to the Flowers of Bhutan and Illustrated Guide to the Orchids of Bhutan) were used for plant survey.

4.3 Methodology

Throughout the Gasa-Lunana transect, permanent reference plots were located based on different altitude range and vegetation cover. However, within a particular altitude zone and vegetation cover, the reference plot was randomly located about 50m away from the main footpath. Using the measuring tape, a plot size of 10m x 10m was measured and established. A total of 14 permanent reference plots was established in the whole transect.

a. Soil Description

In the established reference plot, the soils were examined using a 1.2m Edelman auger fitted with a 7cm combination head. All data were collected on the Soil Auger Form, to ensure uniform data collection and for easy entry into the Bhutan Soil Database (BHUSOD). Prior to actual soil auger description, the following site information were collected and noted along with several other features:

- Site number, survey area name, topographic map and date of description
- Location, GPS coordinates, altitude, general topographic and site position
- Solid, or mapped geology and drift cover or parent material
- The gradient (degree), aspect and form of the slope with estimated run-off and site drainage
- Previous erosion and risk of flooding based on height above the nearest stream line
- Micro-relief, hardness of the surface, presence of capping or cracks
- Estimates (%) of outcropping rock plus stone or gravel cover and any surface litter (organic)
- General land use and current crops/vegetation and any known previous land uses
- Artificial land shaping features, irrigation type plus fertiliser use, if present and if known

A total of 14 auger observations were made in 14 permanent reference plots. While carrying out the auger description, soils were described at every 20cm depth till it reached 100cm or to the depth stopped by gravels and stones. The following data were collected during auger description:

- Horizon number, depth and type
- Soil colour by Munsell colour chart
- Number, size, contrast and colour of mottles
- Field texture including coarse material and particle size class (PSC)
- Number, size, shape, hardness and type of stones
- Reaction to dilute hydrochloric acid (HCl: to test for the presence of free carbonates)
- Number, size, shape, form type, hardness and colour of concentrations or concretions
- Field moisture status of the soil, consistency and plasticity of each horizon in dry, moist and wet condition.

After the soil description, two composite soil samples (topsoil & subsoil) were collected from every reference plot for laboratory analysis. A total of 27 composite samples were collected from 14 permanent reference plots. Soil samples were analyzed at the Soil and Plant Analytical Laboratory (SPAL), NSSC following standard soil analysis method.

b. Plant diversity survey

Plant species diversity was examined in all the 14 reference plots with elevation ranging from 2872 to 4786 masl. Five permanent reference plots were established in Fir forest, three in dry alpine scrubs, two each in Alpine scrubs and meadows and Juniper/rhododendron scrub and one each in Hemlock forest and Rocky outcrops.

Plant diversity survey was done by counting the number of different species in the reference plots. Plant species were mostly identified in the field by a Taxonomist from the National Biodiversity Centre (NBC). However, samples of unidentifiable species were collected for later identification by comparing and referring to the Flora of Bhutan (Vol 1-3), Concise Flowers of the Himalayas, Flowers of the Himalayas –A Supplement, the Photo Guide to the Flowers of Bhutan and Illustrated Guide to the Orchids of Bhutan. Voucher specimens of unidentified plants were collected and compared with herbarium collections at NBC for identification.

The plant species recorded were also compared with the list of High and Low Altitude Medicinal Plants of Bhutan compiled and described by Wangchuk, Samten and Ugyen, 2009 which are used in Bhutanese Traditional Medicine.

5. FINDINGS

The study findings are discussed plot wise and in ascending order with respect to their height above mean sea level.

5.1 Reference Plot-1 (2878 m asl)

The Reference Plot-1 is situated just above the school staff quarter at Gasa (27° 54' 34.4"N and 89° 43' 43.0"E). It has 14° slope gradient with south southeast facing aspect.

5.1.1 Soil

The soil is moderately deep (65cm deep), well-drained with very dark greyish brown sandy loam topsoil underlain by brown sandy clay loam subsoil. Both the topsoil and subsoil are slightly acidic (pH 5.52 to 5.53). The Total Exchangeable Bases (TEB) is very low in both topsoil (1.52me/100g) and subsoil (0.04me/100g). The Base Saturation (BS) is very high in the topsoil (98%) but very low in the subsoil (0.24%). Available phosphorus is very low (2.22ppm) in the topsoil but moderate in the topsoil (3.80ppm). Level of organic carbon in the topsoil is very high (12.30%) and moderate (2.90%) in the subsoil. Total-N is high in the topsoil (0.52%) and moderate in the subsoil (0.26%). The Cation Exchange Capacity (CEC) is very low in the topsoil (1.55me/g) and moderate in the subsoil (18.12me/100g).



5.1.2 Plant diversity

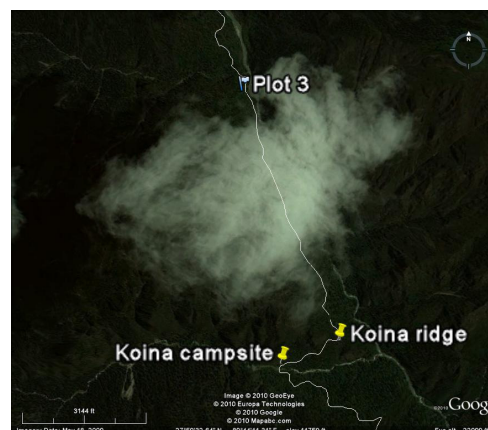
The plot was established in Hemlock forest dominated by *Juniperus recurva*. A total of 32 different species were recorded including five different plant species (*Aster neoelagans*, *Berberis aristata*, *Drosera peltata*, *Pteroccephalodes hookeri* & *Thalictrum reniforme*)

5.2 Reference Plot-3 (3307m asl)

The Reference Plot-3 lies on a fluvial terrace between Koina and Taktsemakha in Laya (28° 00.0' 06.2"N and 89° 44' 06.8"E). It has 28° slope gradient with east northeast facing aspect.

5.2.1 Soil

The soil is very deep (100cm deep), well-drained with black humic loam topsoil and dark grayish brown fine loamy sand subsoil. Both the topsoil and subsoil are very acidic (pH 5.08 to 5.51). The TEB is very high (4.57me/100g) in the topsoil but low (0.61me/100g) in the subsoil. The BS is moderate (40%) in the topsoil but very low (10%) in the subsoil. Available phosphorus is moderate (28.56ppm) in the topsoil and low (11.18ppm) in the subsoil. Level of organic carbon is high (3.60%) in the topsoil and low in the subsoil (1.20%). Total-N is low in the topsoil (0.14%) and moderate in the subsoil (0.23%). The CEC is low in both the topsoil (11.31me/100g) and subsoil (5.8me/100g).



5.2.2 Plant diversity

The plot was established in Fir Forest vegetation zone. The vegetation was mostly *Betula* forest with dead bamboos. Of the 25 species recorded, 3 were found to have medicinal properties (*Berberis aristata*, *Rosa sericea* & *Rubia cordifolia*).

5.3 Reference Plot-4 (3404m asl)

The Reference Plot-4 is located between Laya and Rodhuphu (28° 02.0' 14.1" N and 89° 43' 13.3" E). It has a slope gradient of 35° with southwest facing aspect.

5.3.1 Soil

The soil is very shallow (30cm deep), well-drained with black sandy loam topsoil and brown gravelly sandy loam subsoil. Both the topsoil and subsoil are very acidic (pH 5.15 to 5.34). The TEB is very high (52.34me/100g) in the topsoil and high (23.09me/100g) in the subsoil. The BS is very high in both the topsoil (100%) and subsoil (87%). Available phosphorus is moderate (21.86ppm) in the topsoil and low (3.58ppm) in the subsoil. Level of organic carbon is very high with >15% in the topsoil and 6.10% in the subsoil. Total-N is high in the topsoil (0.82%) and moderate in the subsoil (0.29%). The CEC is very high in the topsoil (49.12me/100g) and high in the subsoil (26.44me/100g).



5.3.2 Plant diversity

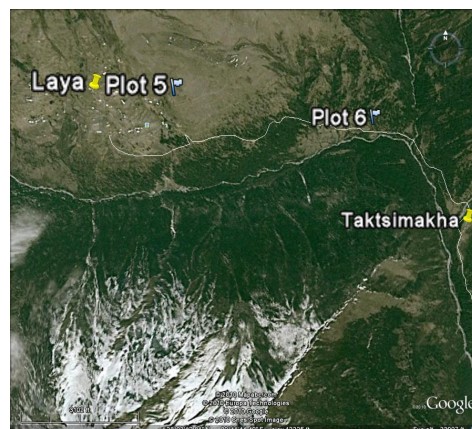
The plot was established in Fir forest with mixed conifer vegetation types. A total of 25 different plant species were recorded. Seven species recorded in this plot were found to be used in Bhutanese Traditional Medicine (*Berberis aristata*, *Halenia elliptica*, *Heracleum obtusifolium*, *Juniperus squamata*, *Panax pseudoginseng*, *Rosa sericea* & *Thalictrum reniforme*).

5.4 Reference Plot-6 (3512m asl)

The Reference Plot-6 is located about 1 km northwest of Taktshimakha in Laya. It has 38° slope gradient with south facing aspect.

5.4.1 Soil

The soil is shallow (50cm deep), well-drained with dark brown sandy loam topsoil underlain by brown gravelly sandy loam subsoil. Both the topsoil and subsoil are slightly acid (pH 5.80 to 5.62). The TEB is very high (14.35me/100g) in the topsoil but low (5.31me/100g) in the subsoil. The BS is high (73%) in the topsoil and moderate (53%) in the subsoil. Available phosphorus is very low in both the topsoil (4.00ppm) and subsoil (2.50ppm). Level of organic carbon is high (4.80%) in the topsoil and moderate in the subsoil (2.50%). Total-N is moderate in the topsoil (0.30%) and low in the subsoil (0.11%). The CEC is moderate in the topsoil (19.87me/100g) and low in the subsoil (10.03me/100g).



5.4.2 Plant diversity

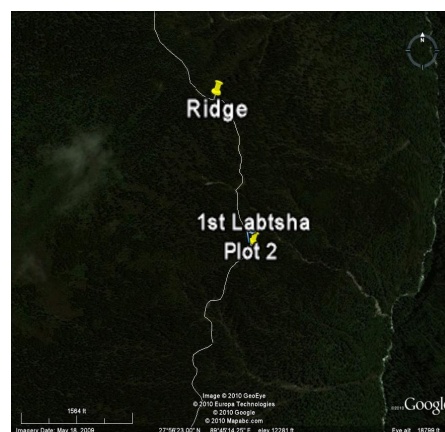
The plot was established in Fir Forest with vegetation dominated by Juniper, Spruce forest with Rosa and Fern. There were 41 species recorded with 9 species found to be used by Bhutanese Traditional Medicine (*Cotoneaster macrophylla*, *Drosera peltata*, *Halenia elliptica*, *Heracleum obtusifolium*, *Juniperus squamata*, *Pedicularis megalantha*, *Pterocephalodes hookeri*, *Rosa macrophylla* & *Thalictrum reniforme*).

5.5 Reference Plot-2 (3546m asl)

The Reference Plot-2 is located near the first Laptsha towards Koina (27° 56' 19.8"N and 89° 45' 17.5"E). It has 25° slope gradient with east facing aspect.

5.5.1 Soil

The soils are moderately shallow (40cm deep), well-drained with very dark gray sandy loam topsoil underlain by brown sandy clay loam subsoil. Both the topsoil and subsoil are very acidic (pH 4.10 to 4.20). The TEB is very low in both the topsoil (2.07me/100g) and subsoil (0.04me/100g). The BS is also very low in both the topsoil (6%) and subsoil (1%). Available phosphorus is very high (10.28ppm) in the topsoil but very low (2.19ppm) in the subsoil. Level of organic carbon is very high with >15.00% in the topsoil and 12.20% in the subsoil. Total-N is high in the topsoil (0.52%) and very low in the subsoil (0.09%). The CEC is high in the topsoil (34.11me/g) and moderate in the subsoil (18.31me/100g).



5.5.2 Plant diversity

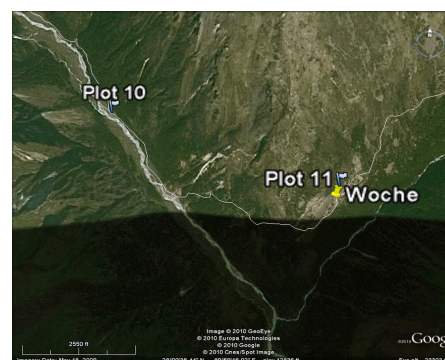
The plot was established in Fir forest vegetation zone. The vegetation was mostly mixed conifer with Rhododendron and Cotoneaster species. Of the 25 species recorded, two were found to be used as medicinal plants by Bhutanese Traditional Medicine (*Cotoneaster macrophylla* & *Rosa sericea*).

5.6 Reference Plot-10 (3656m asl)

The Reference Plot-10 is located in the floodplain before climbing up to Wachi from Tharena Campsite (28° 00.0' 59.4"N and 89° 58' 36.0"E). It has slope gradient of 12° with south southeast facing aspect.

5.6.1 Soil

The soil is very shallow (10cm deep), excessively well-drained with light brownish gray sandy topsoil. Besides repeated augering, it was stopped at 10cm depth due to high content of stone and boulders. The topsoil is slightly acidic (pH 6.01). The TEB and BS are both very low with TEB 0.33me/100g and BS 13%. Available phosphorus is low (6.14ppm). Level of organic carbon is very low (0.50%) and Total-N is low (0.13%) as well. The CEC is very low in the topsoil (2.58me/100g).



5.6.2 Plant diversity

This plot was established in Fir forest vegetation type dominated by Rhododendron. Of the 28 different plant species recorded only one was found to be used in Bhutanese Traditional Medicine (*Aster diplostephioides*).

5.7 Reference Plot-12 (3798m asl)

The Reference Plot-12 is located about 2 hours walk from Threyga village towards Lhedi (28° 00.0' 26.0"N and 90° 03.0' 52.6"E). It has a slope gradient of 28° with east southeast facing aspect.

5.7.1 Soil

The soil is moderately deep (55cm deep), well-drained with very dark grayish brown loam topsoil underlain by yellowish brown sandy clam loam subsoil. The topsoil is very acidic (pH 5.16) but the subsoil is slightly acidic (pH 5.62). The TEB in the topsoil is high (8.35me/100g) but low (4.19me/100g) in the subsoil. The BS is low in both the topsoil (43%) and the subsoil (38%). Available phosphorus is very low (2.71ppm) in both the topsoil and the subsoil. Level of organic carbon is very high in the topsoil (9.00%) and moderate (2.70%) in the subsoil. Total-N is also moderate in both the topsoil (0.58%) and the subsoil (0.27%). The CEC is moderate in the topsoil (19.53me/100g) and low in the subsoil (10.91me/100g)



5.7.2 Plant diversity

This plot established in Juniper/Rhododendron scrub dominated by Juniper, Salix and Rhododendron forest. There were 39 different plant species recorded. Seven species were found to be used in Bhutanese Traditional Medicine (*Aster diplostephioides*, *Ephedra gerardinia*, *Juniperus squamata*, *Leonthopodium himalayanum*, *Onosma hookeri*, *Potentilla anserina* & *Pterocephalodes hookeri*).

5.8 Reference Plot-5 (3910m asl)

The Reference Plot-5 lies about 200m east of proper Laya village (28° 03.0' 49.4"N and 89° 41' 23.2"E). It has 22° slope gradient with southwest facing aspect.

5.8.1 Soil

The soil is deep (100cm deep), well-drained with very dark grayish brown humic loam topsoil and yellowish brown sandy clay loam subsoil. Both the topsoil and subsoil are very acid (pH 5.23 to 5.54). The TEB is very high (6.52me/100g) in the topsoil but very low (0.16me/100g) in the subsoil. The BS is low (31%) in the topsoil and very low (2%) in the subsoil. Available phosphorus is very low in both the topsoil (3.36ppm) and subsoil (4.20ppm). Level of organic carbon is very high in the topsoil (9.60%) and moderate in the subsoil (1.50%). Total-N is very high in the topsoil (9.60%) and high in the subsoil (1.50%). The CEC is moderate in the topsoil (21.23me/100g) and low in the subsoil (10.45me/100g).



5.8.2 Plant diversity

The plot was established in Alpine scrub and meadows where the vegetation was dominated by alpine meadows. Of the 26 species recorded, seven were found to be used in Bhutanese Traditional Medicine (*Cotoneaster macrophylla*, *Halenia elliptica*, *Juniperus squamata*, *Leonthopodium himalayanum*, *Onosma hookeri*, *Pterocephalodes hookeri* & *Rhododendron setosum*).

5.9 Reference Plot-11 (3942m asl)

The Reference Plot-11 is located about 50m northwest of Woche campsite on the mid slope of the mountain ($28^{\circ} 00.0' 36.6''$ N and $89^{\circ} 59' 46.5''$ E). It has southerly aspect with 17° slope gradient.

5.9.1 Soil

The soil is very deep (100cm deep), well-drained with very dark brown humic loam topsoil and light olive brown silty clay loam subsoil. Both the topsoil and subsoil are extremely acidic (pH 4.18 to 4.55). The subsoil TEB and BS is very low (0.68me/100g and 3% respectively). Available phosphorus in the subsoil is very low (2.77ppm) and low (10.24ppm) in the topsoil. Level of organic carbon is very high with >15.00% in the topsoil and 6.30% in the subsoil. Total-N is very low in the topsoil (0.08%) and moderate in the subsoil (0.34%). The CEC in the topsoil is not determined but it is moderate in the subsoil (22.39me/100g).



5.9.2 Plant diversity

The plot was established in Juniper/Rhododendron scrub type of vegetation dominated by Rhododendron. Of the 42 different plant species recorded, which was the highest number of species recorded, 6 were found to be used in Bhutanese Traditional Medicine (*Berberis aristata*, *Juniperus squamata*, *Pedicularis megalantha*, *Rosa sericea*, *Saxifraga parnassifolia* & *Thalictrum reniforme*).

5.10 Reference Plot-14 (4140m asl)

The Reference Plot-14 is located about 300m north of Tshoju Lhaxhang, Lunana ($28^{\circ} 03.0' 58.9''$ N and $90^{\circ} 09.0' 53.0''$ E). It has a slope gradient of 27° with southerly aspect.

5.10.1 Soil

The soil is deep (100cm deep), well-drained with dark brown humic loam topsoil and yellowish brown fine sandy clay loam subsoil. The topsoil is very acidic (pH 5.46) and the subsoil is slightly acidic (pH 5.67). The TEB is high in the topsoil (12.91me/100g) and low in the subsoil (4.60me/100g). The BS is very high in the topsoil (100%) but low in the subsoil (35%). Available phosphorus is very low in both the topsoil (2.44ppm) and the subsoil (2.47ppm). Level of organic carbon is very high in both the topsoil (4.90%) and the subsoil (3.20%). Total-N is low in both the topsoil (0.16%) and the subsoil (0.14%). The CEC is low in both the topsoil (10.52me/100g) and the subsoil (13.06me/100g).



5.10.2 Plant diversity

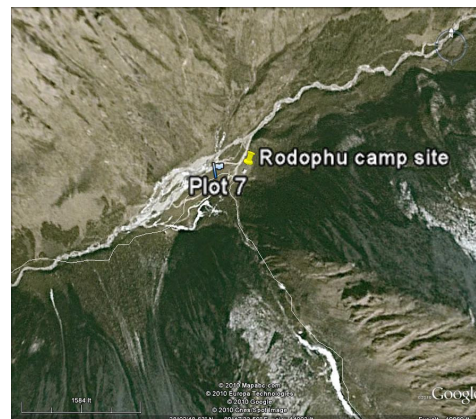
The plot was established in Alpine scrub and meadows vegetation zone dominated by alpine meadows. Of the 30 different plant species recorded, 7 were found to be used in Bhutanese Traditional Medicine (*Aster diplostephioides*, *Cotoneaster macrophylla*, *Juniperus squamata*, *Nardostachys hookeri*, *Onosma hookeri*, *Pedicularis megalantha* & *Potentilla anserine*).

5.11 Reference Plot-7 (4238m asl)

The Reference Plot-7 is located about 150 m away from the Rodophu camp site (28° 02.0' 23.7"N and 89° 47' 28.4"E) in the floodplain.

5.11.1 Soil

The soil is very shallow (30cm deep), well-drained with very dark grayish brown fine loamy sand topsoil and brown fine sand subsoil. Both the topsoil and subsoil are very acid (pH 5.45 to 5.41). The TEB is low (4.78me/100g) in the topsoil and very low (0.64me/100g) in the subsoil. The BS is moderate (66%) in the topsoil but very high (100%) in the subsoil. Available phosphorus for topsoil is moderate (12.32ppm) but low (7.17ppm) in the subsoil. Level of organic carbon is low (0.80%) in the topsoil and very high in the subsoil (5.20%). Total-N is low in the topsoil (0.14%) and very low in the subsoil (0.08). The CEC is low in the topsoil (7.21me/100g) and very low in the subsoil (0.45me/100g).



5.11.2 Plant diversity

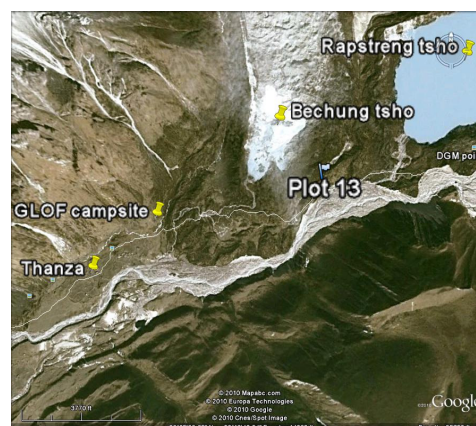
The plot was established in dry alpine scrub type of vegetation zone dominated by dwarf Rhododendron. Here 19 different plants species were recorded, of which three were found to be used in Bhutanese Traditional Medicine (*Juniperus squamata*, *Pedicularis siphonanthae* & *Rhododendron anthopogon*).

5.12 Reference Plot-13 (4333m asl)

The Plot-13 is located about ½ hr walk from Rapstreng Tsho towards Thanza, Lunana (28° 05.0' 49.4"N and 90° 14.0' 04.3"E). It is facing south east (SE) aspect with slope gradient of 31°.

5.12.1 Soil

The soil is moderately shallow (50cm deep), well-drained with dark grayish brown sandy loam topsoil and dark brown sandy loam subsoil. Both the topsoil and subsoil are very acidic (pH 5.22 to 5.10). The TEB is low (3.75me/100g) in the topsoil and very low (0.97me/100g) in the subsoil. The BS is low in the topsoil (37%) and very low in the subsoil (9%). Available phosphorus is very low in both the topsoil (2.50ppm) and subsoil (2.67ppm). Level of organic carbon is high both in the topsoil (4.50%) and subsoil (4.40%). Total-N is moderate in the topsoil (0.40%) and low in the subsoil (0.11%). The CEC is low in both the topsoil (10.12me/100g) and the subsoil (11.42me/100g).



5.12.2 Plant diversity

The plot was established in dry alpine scrub vegetation zone dominated by Juniper. Of the 40 different species recorded, 10 species were found to be used in Bhutanese Traditional Medicine (*Aster diplostephioides*, *Berberis aristata*, *Ephedra gerardina*, *Halenia elliptica*, *Juniperus squamata*, *Onosma hookeri*, *Pedicularis siphonanthae*, *Potentilla fructifera*, *Saxifraga parnassifolia* & *Thalictrum reniforme*).

5.13 Reference Plot-9 (4687m asl)

The Plot-9 is located about 3 hours walk from Narethang campsite (28° 04.0' 11.9" N and 89° 53' 38.7" E). It has north facing slope with 5° slope gradient.

5.13.1 Soil

The soil is very shallow (25cm deep), well-drained with black humic loam topsoil and dark yellowish brown gravelly loamy sand subsoil. Both the topsoil and subsoil are very acid (pH 5.02 to 5.32). The TEB is high in the topsoil (10.30me/100g) but very low in the subsoil (0.07me/100g). The BS is low in the topsoil (39%) but very low in the subsoil (2%). Available phosphorus is very low in the topsoil (4.07ppm) and low in the subsoil (6.12ppm). Level of organic carbon is very high in the topsoil (>15.00%) and high in the subsoil (3.40%). Total-N is high in the topsoil (0.62%) and low in the subsoil (0.10%). The CEC is high in the topsoil (26.14me/100g) and very low in the subsoil (4.61me/100g).



5.13.2 Plant diversity

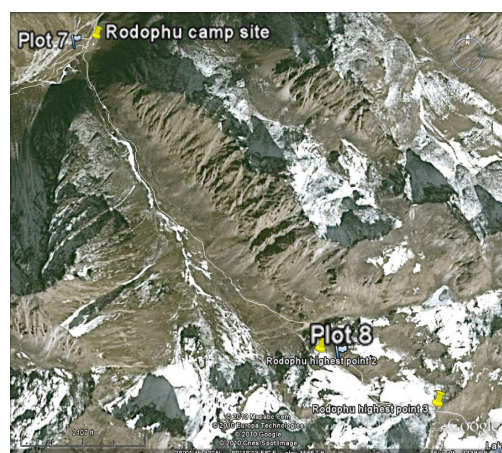
The plot was established in dry alpine scrub type of vegetation zone dominated by dwarf Rhododendrons. Of the total 19 different species recorded, 5 were found to be used in Bhutanese Traditional Medicine (*Pedicularis megalantha*, *Picrorhiza kurroo*, *Rhododendron anthopogon*, *Sassurea gossiphiflora* & *Sassurea obvallata*).

5.14 Reference Plot-8 (4786m asl)

The Reference Plot-8 is located about 2 hours walk from Rodophu campsite towards Lunana (28° 01.0' 23.9" N and 89° 48' 30.1" E). It is basically on a moraine deposit and has a slope gradient of 7° with northwest facing aspect.

5.14.1 Soil

The soil is shallow (40cm deep), well-drained with black humic loam topsoil underlain by yellowish brown gravelly loamy sand subsoil. Both the topsoil and subsoil are very acid (pH 5.05 to 5.35). The TEB is very low in both the topsoil (0.92me/100g) and the subsoil (0.17me/100g). The BS is moderate in the topsoil (52%) but very low in the subsoil (2%). Available phosphorus for the topsoil is very low (4.33ppm) but low in the subsoil (13.20ppm). Level of organic carbon is very high (7.30%) in the topsoil and low in the subsoil (1.00%). Total-N is moderate in the topsoil (0.41%) and very low in the subsoil (0.09%). The CEC is very low in the topsoil (1.76me/100g) and low in the subsoil (10.37me/100g).



5.14.2 Plant diversity

The plot was established in rocky outcrop type of vegetation zone dominated by *Rheum nobile*. Here total of 14 species were recorded, which was the lowest recorded. Three different medicinal plants were recorded (*Rheum emodi*, *Rheum nobile* & *Sassurea gossiphiflora*).

5.15 Summary of soil and plant information

Table 1 Summary of soil information

Topsoil										
Plot#	Alt (m)	pH (H ₂ O)	AvP (mg/kg)	AvK (mg/kg)	OC (%)	Total N (%)	TEB (me/100g)	CEC (me/100g)	BS (%)	Vegetation Zone
Plot-1	2878	5.53	2.22	65.45	12.3	0.52	1.52	1.55	98	Hemlock forest
Plot-3	3307	5.08	28.56	48.2	3.6	0.14	4.57	11.31	40	Fir forest
Plot-4	3404	5.15	21.86	215.57	>15	0.82	52.34	49.12	100	Fir forest
Plot-6	3512	5.8	4	122.26	4.8	0.3	14.35	19.87	72	Fir forest
Plot-2	3546	4.1	10.28	55.61	12.2	0.52	2.07	34.11	6	Fir forest
Plot-10	3656	6.01	6.14	5.51	0.5	0.13	0.33	2.58	13	Fir forest
Plot-12	3798	5.16	2.71	50.18	9	0.58	8.35	19.53	43	Juniper/Rhodo scrub
Plot-5	3910	5.23	3.36	92.47	9.6	0.46	6.52	21.23	31	Alpine scrub & meadows
Plot-11	3942	4.18	10.24	198.29	>15	0.08	4.09	50.7	8	Juniper/Rhodo scrub
Plot-14	4140	5.46	2.44	59.47	4.9	0.16	12.91	10.52	100	Alpine scrub & meadows
Plot-7	4238	5.45	12.32	45.58	0.8	0.14	4.78	7.21	66	Dry alpine scrub
Plot-13	4333	5.22	2.5	29.94	4.5	0.4	3.75	10.12	37	Dry alpine scrub
Plot-9	4687	5.02	4.07	32.15	>15	0.62	10.3	26.14	39	Dry alpine scrub
Plot-8	4789	5.05	4.33	15.78	7.3	0.41	0.92	1.76	52	Rocky outcrops
Subsoil										
Plot#	Alt (m)	pH (H ₂ O)	AvP (mg/kg)	AvK (mg/kg)	OC (%)	Total N (%)	TEB (me/100g)	CEC (me/100g)	BS (%)	Vegetation Zone
Plot-1	2878	5.52	3.8	9.55	2.9	0.26	0.04	18.12	1	Hemlock forest
Plot-3	3307	5.51	11.18	25.48	1.2	0.23	0.61	5.8	10	Fir forest
Plot-4	3404	5.34	3.58	54.29	6.1	0.29	23.09	26.44	87	Fir forest
Plot-6	3512	5.62	2.5	35.39	2.5	0.11	5.31	10.03	53	Fir forest
Plot-2	3546	4.21	2.19	15.3	>15	0.09	0.04	18.31	1	Fir forest
Plot-10	3656	NS	NS	NS	NS	NS	NS	NS	NS	Fir forest
Plot-12	3798	5.62	2.71	36.46	2.7	0.27	4.19	10.91	38	Juniper/Rhodo scrub
Plot-5	3910	5.54	4.2	3.29	1.5	0.09	0.16	10.45	2	Alpine scrub & meadows
Plot-11	3942	4.55	2.77	39.2	6.3	0.34	0.68	22.39	3	Juniper/Rhodo scrub
Plot-14	4140	5.67	2.47	28.48	3.2	0.14	4.6	13.06	35	Alpine scrub & meadows
Plot-7	4238	5.41	7.17	16.45	5.20	0.08	0.64	0.45	100	Dry alpine scrub
Plot-13	4333	5.1	2.67	12.34	4.4	0.11	0.97	11.42	9	Dry alpine scrub
Plot-9	4687	5.32	6.22	13	3.4	0.1	0.07	4.61	2	Dry alpine scrub
Plot-8	4789	5.35	13.2	0.05	1	0.09	0.17	10.37	2	Rocky outcrops

Table 2 Summary of plant information

Plot#	Altitude (m)	Species recorded	Vegetation description	Vegetation zone
Plot-1	2872	32	Dominated by <i>Juniperus recurva</i>	Hemlock forest
Plot-3	3307	25	Betula Forest with dead bamboos	Fir forest
Plot-4	3404	25	Mixed conifer forest	Fir forest
Plot-6	3512	41	Juniper, Spruce forest with Rosa and fern	Fir forest
Plot-2	3656	28	Rhododendron scrub	Fir forest
Plot-10	3692	25	Mixed conifer with Rhododendron and Cotoneaster sp.	Fir forest
Plot-12	3795	39	Juniper, Salix and Rhododendron forest	Juniper/Rhododendron scrub
Plot-5	3910	26	Alpine meadow	Alpine scrub and meadows
Plot-11	3942	42	Rhododendron scrub	Juniper/Rhododendron scrub
Plot-14	4140	30	Alpine meadow	Alpine scrub and meadows
Plot-7	4238	19	Open scrub with dwarf Rhododendrons	Dry alpine scrub
Plot-13	4333	40	Juniper forest	Dry alpine scrub
Plot-9	4687	19	Rhododendron scrub	Dry alpine scrub
Plot-8	4786	14	Rocky with good distribution of <i>Rheum nobile</i>	Rocky outcrops

The highest number of 42 plant species was recorded at an elevation of 3942 m asl under Rhododendron scrub vegetation zone, while the lowest number of 14 plant species was recorded at an elevation of 4786 m asl under rocky outcrop vegetation zone (see Table 1). The plant species record in different reference plots is attached as Annex - 2.

The most common species recorded was *Poa* species which was recorded in 11 different plots, while *Carex* species and *Juniperous squamato* was recorded in 8 different plots. *Anaphalis busua* and *Bistorta affinis* was recorded in 7 and 6 different plots respectively.

A total of 30 different medicinal plants were recorded. The highest number of medicinal plants recorded was in plot# 13 at an altitude of 4333 masl, with 10 different species. Nine different medicinal plants species were recorded at plot# 9 at an altitude of 4687 masl. The lowest of one medicinal plant was recorded at plot# 10 at an altitude of 3656 masl. *Juniperus squamata* was the most widely distributed medicinal plants recorded at 8 different plots.

6. DISCUSSIONS

Jenny (1929) noted that soils of alpine areas are darker and richer in humus than those of lowlands. Until now, only a few systematic studies support this early suggestion of a larger C accumulation in the high altitude soils (Leifeld et al., 2009). Sheikh et al (2009), however observed decreasing trend in soil organic carbon with increasing altitudes. The decreasing trend of C is mainly attributed to the lower mineralization rate and net nitrification rate at the higher altitudes. While soil inventories in Switzerland and Austria do not reveal significant altitudinal increase in Total C storage (Perruchoud et al 2000). However, Leifeld et al (2009) and Sjogersten et al (2003) observed increasing fractions of particulate and liable SOM increasing with increasing altitude in grassland and natural tree line ecosystem. The storage of large amounts of organic C in liable pools in mountain soils implies a high vulnerability of these soils to loose C when abiotic and biotic conditions are altered by a changing climate and land use (Hagedorn et al 2009).

The current study shows no significant difference in soil organic carbon along different altitudinal gradient. Instead, the soil organic C seems to vary significantly under different vegetation cover types. As reported by Sheikh et al (2009), the current study also shows decrease in soil organic C content with increase in soil depth. This is probably due to greater microbial activity in the topsoil which enhances decomposition of organic matter.

In general, alpine soils are slightly more acidic compared to lowland soils. This is because of low mineralization rate and net nitrification rate in the high altitude areas. The current study also depicts a slight decrease in soil pH with increase in altitude. On an average, the topsoil pH is slightly lower than the subsoil probably due to again low mineralization rate and net nitrification rate in the topsoil compared to subsoil.

Sheikh et al (2009) found out a characteristic decline in total tree density, species diversity and basal area with increasing altitude in the Himalayan forest. The current study also slightly indicates this trend though not very apparent. The decrease in species richness in high elevation strata could be due to eco-physiological constraints, low temperature and low productivity of the soils. However, increased plant diversity was noticed wherever there were human disturbances.

7. LIMITATIONS

- The soil information provided above is based on the soil auger description and not on the soil profile description. Therefore soils were not described in great detail.
- Due to absence of floral parts of some of the plant species during the study period (September - October), identification of these plant species have been possible only up to genus level.
- While doing the plant survey, attempt was made to record the floral diversity only.

8. CONCLUSIONS

The main aim of this study was to establish permanent reference plots in the high altitude areas and collect soil and plant resource information to facilitate future studies on the dynamics of soil and plant resources vis-à-vis climate change impacts and human interventions in the country. These permanent reference plots are also meant to serve as reference points for future studies in the field of environment in the country.

A total of 14 permanent reference plots measuring 10m x 10m were established along the Gasa – Lunana transect under different altitudinal and vegetation zones. Detailed soil auger description and plant survey were done in every reference plot to collect soil and plant diversity information. Composite soil samples were collected from the topsoil and subsoil for laboratory analysis. Rapid plant diversity survey was done within the permanent reference plots. Specimens of some plant species that could not be identified on the spot were collected for later identification and also for the herbarium at NBC.

Due to young parent materials and extreme climatic condition, soil development in the study area is very limited. Soils are generally very shallow and stony. Soil organic carbon is quite comparable throughout the altitudinal transect however, it decreases with increase in soil depth. The soil pH decreases slightly with increase in altitude but it increases with increase in soil depth. Plant diversity decreases with increase in elevation due to eco-physiological constraints, low temperature and low productivity of the soils. However, increased plant diversity was noticed wherever there were human disturbances.

The study was conducted by the Department of Agriculture from 15th Sept. to 4th Oct 2010 (20 days) with financial assistance from the GEF/UNDP funded MSP Project based at the National Soil Services Centre (NSSC), Semtokha.

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10. TRAVEL ITINERARY

Date	Station
15/9/2010	Thimphu to Gasa
16/9/2010	Halt at Gasa Established a reference plot at Phulakha
17/9/2010	Gasa to Koina Established a reference plot at Lapsakha
18/9/2010	Koina to Taktsemakha Established a reference plot near Taktsemakha
19/9/2010	Taktsemakha to Laya Established reference plots at Laya
20/9/2010	Laya to Rodophu Established reference plot at Rhodophu
21/9/2010	Rodophu to Narithang Established a reference plot near Kanglakarchung
22/9/2010	Narithang to Tarina Established a reference plot
23/9/2010	Tarina to Woche Established a reference plot at Woche
24/9/2010	Woche to Hedi Established reference
25/9/2010	Hedi to Threyga Established reference plot at Threykha
26/9/2010	Threyga to Thangza Established reference plot at Thangza
27 Sept - 4 Oct. 2010	Thangza to Thimphu

ANNEX - 1 SOIL AUGER DESCRIPTIONS

Auger:	AP0383 (Plot-1)
Described & sampled:	Tshering Dorji & Kinley Penjor
Survey area:	Phulakha, Gasa
Map unit:	
Soil Classification	
BSS Soil Series:	
Soil Taxonomy:	ND
WRB:	ND
Coordinates:	27° 54' 34.4" N and 89° 43' 43.0" E
Topographic Map:	No. 78E09, Scale 50000
Location:	Ca 100m NW from the teacher's staff quarter in Gasa
Altitude:	2878 masl
Climate	
General:	Sub-alpine
Recent Weather:	Cloudy
Parent material	
Solid:	Thimphu, gneiss
Drift:	Colluvium
Topography	
Landform:	High Mountain
Site position:	Upper slope
Aspect:	SSE (158°)
Slope:	14° (steep), concave
Erosion:	Slight, splash
Site drainage:	Good
Microrelief:	25 - 50cm from undulations
Surface condition:	Wet, soft
Surface cracks:	None
Surface capping:	None
Lichen/Algae:	None
Surface litter:	Overall, raw decomposed grass about 1cm deep.
Surface outcrops:	Rare (1%), hard subangular gneiss & granite boulders
Surface stone:	None
Land category:	Government forest
Landuse:	Government forest
Soil Depth Limit:	Gravel & stone contact at 60 cm
Soil Drainage Class:	Well drained
Notes / Comments:	ND

Cm	Horizon Type	Description
0-20	Ah	Very dark grayish brown (10YR 3/2) moist; sandy loam with no mottles; rare hard subangular fine granite gravels; no concretions; moist & slightly firm; non sticky and non plastic; no reaction to dilute HCl
20-50	B	Brown (10YR 4/3) moist; sandy clay loam with no mottles; rare hard subangular fine granite gravels; no concretions; moist & firm; sticky and plastic; no reaction to dilute HCl
50-65	BC	Yellowish brown (10YR 5/6) moist; silty clay loam with no mottles; no stones; no concretions; moist & firm; sticky and plastic; no reaction to dilute HCl

SPAL analytical results for Auger AP0383 (Plot-1)

Survey area: Gasa / Lunana transect

Reaction, P, K & organic matter

SSU No.	Depth cm	Lab No	pH			EC mS/cm	Avail.P ppm	Avail.K ppm	OC %	Total N %	C:N
			H2O	KCl	Diff						
AP 0383 TS	0-20	35436	5.53	4.51	1.02	ND	2.22	65.45	12.30	0.52	23.88
AP 0383 SS	20-65	35437	5.52	4.90	0.62	ND	3.80	9.55	2.90	0.26	11.03

Exchangeable base status

SSU No.	Exchangeable (me/100g)				TEB	Extr Al	CEC		BS%	
	Ca	Mg	K	Na			AmOAc	ECEC	AmOAc	EBS%
AP 0383 TS	0.50	0.47	0.40	0.15	1.52	ND	1.55	ND	98.33	ND
AP 0383 SS	0.27	0.04	0.14	0.14	0.04	ND	18.12	ND	0.24	ND

Fine earth granulometric

SSU No.	Sand						Silt			Clay	Texture class
	>1000 micron	425- 1000	212- 425	106- 212	50-106	Total sand	20-50 micron	2-20	Total silt		
AP 0383 TS	ND	ND	ND	ND	ND	28.40	11.90	32.70	44.60	27.00	L
AP 0383 SS	ND	ND	ND	ND	ND	27.10	13.50	37.60	51.10	21.80	ZL

Auger: **AP0384 (Plot-2)**
 Described & sampled: Tshering Dorji & Kinley Penjor
 Survey area: Laptsakha, Gasa
 Map unit:
 Soil Classification
 BSS Soil Series:
 Soil Taxonomy: ND
 WRB: ND
 Coordinates: 27°56' 19.8" N and 89° 45' 17.5" E
 Topographic Map: No. 78E09, Scale 50000
 Location: Ca 50m NW of the 1st Laptsa towards Koina
 Altitude: 3546 masl
 Climate
 General: Sub-alpine
 Recent Weather: Sunny
 Parent material
 Solid: Thimphu, gneiss
 Drift: Colluvium
 Topography
 Landform: High Mountain
 Site position: Upper slope
 Aspect: E (91°)
 Slope: 25° (very steep), concave
 Erosion: None
 Site drainage: Moderate
 Microrelief: 25 - 50 cm from root stepping
 Surface
 Surface condition: Wet, slightly hard
 Surface cracks: None
 Surface capping: None
 Lichen/Algae: None
 Surface litter: Overall, raw decomposed mosses and leaves about 10 cm deep.
 Surface outcrops: Few (3%), hard subrounded gneiss & granite boulders
 Surface stone: None
 Land category: Government forest
 Landuse: Government forest
 Soil Depth Limit: Gravel & stone contact at 40 cm
 Soil Drainage Class: Well drained
 Notes / Comments: ND

Cm	Horizon Type	Description
0-30	Ah	Very dark gray (10YR 3/1) moist; sandy loam with no mottles; few slightly hard subangular fine quartzite gravels; no concretions; moist & slightly friable; non sticky and non plastic; no reaction to dilute HCl
30-40	Bw	Brown (10YR 4/3) moist; sandy clay loam with no mottles; common slightly hard angular fine quartzite gravels; no concretions; moist & slightly firm; slightly sticky and slightly plastic; no reaction to dilute HCl.

SPAL analytical results for Auger AP0384 (Plot-2)

Survey area: Gasa / Lunana transect

Reaction, P, K & organic matter

SSU No.	Depth cm	Lab No	pH			EC mS/cm	Avail.P ppm	Avail.K ppm	OC %	Total N %	C:N
			H2O	KCl	Diff						
AP 0384 TS	0-30	35438	4.10	3.45	0.65	ND	10.28	55.61	12.20	0.52	23.45
AP 0384 SS	30-40	35439	4.21	3.73	0.48	ND	2.19	15.30	>15.00	0.09	ND

Exchangeable base status

SSU No.	Exchangeable (me/100g)				TEB	Extr Al	CEC		BS%	
	Ca	Mg	K	Na			AmOAc	ECEC	AmOAc	EBS%
AP 0384 TS	1.16	0.52	0.23	0.17	2.07	ND	34.11	ND	6	ND
AP 0384 SS	0.26	0.08	0.08	0.14	0.04	ND	18.31	ND	1	ND

Fine earth granulometric

SSU No.	Sand						Silt			Clay	Texture class
	>1000 micron	425- 1000	212- 425	106- 212	50-106	Total sand	20-50 micron	2-20	Total silt		
AP 0384 TS	ND	ND	ND	ND	ND	56.20	6.80	26.00	32.80	11.00	SL
AP 0384 SS	ND	ND	ND	ND	ND	62.10	1.90	8.40	10.30	27.60	SCL

Auger:	AP0385 (Plot-3)
Described & sampled:	Tshering Dorji & Kinley Penjor
Survey area:	Koina, Gasa
Map unit:	
Soil Classification	
BSS Soil Series:	
Soil Taxonomy:	ND
WRB:	ND
Coordinates:	28° 00.0' 06.2" N and 89° 44' 06.8" E
Topographic Map:	No. 78E09, Scale 50000
Location:	Ca 2 hrs walking distance from Koina towards Taktsimakha camp site
Altitude:	3307 masl
Climate	
General:	Sub alpine
Recent Weather:	Sunny
Parent material	
Solid:	Thimphu, gneiss
Drift:	Alluvium
Topography	
Landform:	Plain
Site position:	Fluvial terrace
Aspect:	ENE (72°)
Slope:	28° (very steep), concave
Erosion:	None
Site drainage:	Good
Microrelief:	< 25cm from undulations
Surface	
Surface condition:	Wet, slightly hard
Surface cracks:	None
Surface capping:	None
Lichen/Algae:	None
Surface litter:	Overall, raw decomposed leaves & mosses about 5 cm deep
Surface outcrops:	Rare (1%), hard subangular gneiss boulders
Surface stone:	None
Land category:	Government forest
Landuse:	Government forest
Soil Depth Limit:	No
Soil Drainage Class:	Well drained
Notes / Comments:	ND

Cm	Horizon Type	Description
0-10	Ah	Black (10YR 2/1) moist; humic loam with no mottles; no stones; no concretions; moist & friable; non sticky and non plastic; no reaction to dilute HCl
10-50	Bw	Dark brown (10YR 3/3) moist; gravelly loamy sand with no mottles; few hard subangular fine quartzite and gneiss gravels; no concretions; moist & friable; non sticky and non plastic; no reaction to dilute HCl
50-100	Bw1	Dark grayish brown (2.5Y 4/2) moist; fine loamy sand with no mottles; no stones; no concretions; moist & slightly firm; non sticky and non plastic; no reaction to dilute HCl

SPAL analytical results for Auger AP0385 (Plot-3)

Survey area: Gasa / Lunana transect

Reaction, P, K & organic matter

SSU No.	Depth cm	Lab No	pH			EC mS/cm	Avail.P ppm	Avail.K ppm	OC %	Total N %	C:N
			H2O	KCl	Diff						
AP 0385 TS	0-20	35440	5.08	4.29	0.79	ND	28.56	48.20	3.60	0.14	25.28
AP 0385 SS	20-100	35441	5.51	4.59	0.92	ND	11.18	25.48	1.20	0.23	5.16

Exchangeable base status

SSU No.	Exchangeable (me/100g)				TEB	Extr Al	CEC		BS%	
	Ca	Mg	K	Na			AmOAc	ECEC	AmOAc	EBS%
AP 0385 TS	3.35	0.90	0.18	0.13	4.57	ND	11.31	ND	40	ND
AP 0385 SS	0.07	0.17	0.14	0.22	0.61	ND	5.80	ND	10	ND

Fine earth granulometric

SSU No.	Sand						Silt			Clay	Texture class
	>1000 micron	425-1000	212-425	106-212	50-106	Total sand	20-50 micron	2-20	Total silt		
AP 0385 TS	ND	ND	ND	ND	ND	72.40	11.00	12.00	23.00	4.60	SL
AP 0385 SS	ND	ND	ND	ND	ND	62.90	15.10	16.30	31.40	5.70	SL

Auger: **AP0386 (Plot-4)**

Described & sampled: Tshering Dorji & Kinley Penjor

Survey area: Near Taktshimakha, Laya/Gasa

Map unit:

Soil Classification

BSS Soil Series:

Soil Taxonomy: ND

WRB: ND

Coordinates: 28° 02.0' 14.1" N and 89° 43' 13.3" E

Topographic Map: No. 77H12, Scale 50000

Location: Ca 70m E of Rodophu and Laya junction

Altitude: 3404 masl

Climate

General: Sub-alpine

Recent Weather: Sunny

Parent material

Solid: Thimphu, gneiss

Drift: Colluvium

Topography

Landform: Mountain

Site position: Lower slope

Aspect: SW (233°)

Slope: 35° (extremely steep), concave

Erosion: None

Site drainage: Good

Microrelief: 25-50cm from undulations

Surface

Surface condition: Moist, hard

Surface cracks: None

Surface capping: None

Lichen/Algae: None

Surface litter: Overall, raw decomposed leaves & mosses about 5 cm deep

Surface outcrops: Common (15%), hard subangular gneiss & granite boulders

Surface stone: None

Land category: Government forest

Landuse: Government forest

Soil Depth Limit: Gravels & stone contact at 30cm deep

Soil Drainage Class: Well drained

Notes / Comments: ND

Cm	Horizon Type	Description
0-10	Ah	Black (10YR 2/1) moist; sandy loam with no mottles; no stones; no concretions; moist & friable; non sticky and non plastic; no reaction to dilute HCl
10-30	Bw	Brown (10YR 4/3) moist; gravelly sandy loam with no mottles; common slightly hard subangular fine quartzite gravels; no concretions; moist & friable; non sticky and non plastic; no reaction to dilute HCl

SPAL analytical results for Auger AP0386 (Plot-4)

Survey area: Gasa / Lunana transect

Reaction, P, K & organic matter

SSU No.	Depth cm	Lab No	pH			EC mS/cm	Avail.P ppm	Avail.K ppm	OC %	Total N %	C:N
			H2O	KCl	Diff						
AP 0386 TS	0-20	35442	5.15	4.55	0.60	ND	21.86	215.57	>15	0.82	ND
AP 0386 SS	20-30	35443	5.34	4.64	0.70	ND	3.58	54.29	6.10	0.29	20.85

Exchangeable base status

SSU No.	Exchangeable (me/100g)				TEB	Extr Al	CEC		BS%	
	Ca	Mg	K	Na			AmOAc	ECEC	AmOAc	EBS%
AP 0386 TS	46.81	4.39	1.00	0.15	52.34	ND	49.12	ND	100	ND
AP 0386 SS	20.07	2.31	0.36	0.36	23.09	ND	26.44	ND	87	ND

Fine earth granulometric

SSU No.	Sand						Silt			Clay	Texture class
	>1000 micron	425-1000	212-425	106-212	50-106	Total sand	20-50 micron	2-20	Total silt		
AP 0386 TS	ND	ND	ND	ND	ND	46.00	6.70	27.10	33.80	20.20	L
AP 0386 SS	ND	ND	ND	ND	ND	56.10	8.60	22.70	31.30	12.60	SL

Auger:	AP0387 (Plot-5)
Described & sampled:	Tshering Dorji & Kinley Penjor
Survey area:	Laya, Gasa
Map unit:	
Soil Classification	
BSS Soil Series:	
Soil Taxonomy:	ND
WRB:	ND
Coordinates:	28° 03.0' 49.4" N and 89° 41' 23.2" E
Topographic Map:	No. 77H12, Scale 50000
Location:	Ca 200m E of Laya village
Altitude:	3910 masl
Climate	
General:	Alpine
Recent Weather:	Sunny but windy
Parent material	
Solid:	Thimphu, gneiss
Drift:	Colluvium
Topography	
Landform:	High Mountain
Site position:	Upper slope
Aspect:	SW (230°)
Slope:	22° (very steep), concave
Erosion:	Slight, splash
Site drainage:	Good
Microrelief:	< 25cm from undulations
Surface	
Surface condition:	Moist, soft
Surface cracks:	None
Surface capping:	None
Lichen/Algae:	None
Surface litter:	Overall, raw decomposed mosses and leaves about 1 cm deep.
Surface outcrops:	Few (3%), hard subangular gneiss boulders
Surface stone:	None
Land category:	Government forest
Landuse:	Government forest
Soil Depth Limit:	No
Soil Drainage Class:	Well drained
Notes / Comments:	ND

Cm	Horizon Type	Description
0-15	Ah	Very dark grayish brown (10YR 3/2) moist; humic loam with no mottles; no stones; no concretions; moist & friable; non sticky and non plastic; no reaction to dilute HCl
15-40	Bw	Dark brown (10YR 3/3) moist; sandy loam with no mottles; few slightly hard subangular fine gneiss gravels; no concretions; moist & slightly friable; non sticky and non plastic; no reaction to dilute HCl
40-100	Bw1	Yellowish brown (10YR 5/6) moist; sandy clay loam with no mottles; few slightly hard subangular fine gneiss gravels; no concretions; moist & slightly firm; slightly sticky and slightly plastic; no reaction to dilute HCl

SPAL analytical results for Auger AP0387 (Plot-5)

Survey area: Gasa / Lunana transect

Reaction, P, K & organic matter

SSU No.	Depth cm	Lab No	pH			EC mS/cm	Avail.P ppm	Avail.K ppm	OC %	Total N %	C:N
			H2O	KCl	Diff						
AP 0387 TS	0-20	35444	5.23	4.40	0.83	ND	3.36	92.47	9.60	0.46	0.46
AP 0387 SS	20-100	35445	5.54	4.79	0.75	ND	4.20	3.29	1.50	0.09	0.09

Exchangeable base status

SSU No.	Exchangeable (me/100g)				TEB	Extr Al	CEC		BS%	
	Ca	Mg	K	Na			AmOAc	ECEC	AmOAc	EBS%
AP 0387 TS	5.16	0.64	0.60	0.12	6.52	ND	21.23	ND	31	ND
AP 0387 SS	0.10	0.02	0.11	0.12	0.16	ND	10.45	ND	2	ND

Fine earth granulometric

SSU No.	Sand						Silt			Clay	Texture class
	>1000 micron	425- 1000	212- 425	106- 212	50-106	Total sand	20-50 micron	2-20	Total silt		
AP 0387 TS	ND	ND	ND	ND	ND	52.90	12.80	23.70	36.50	10.60	SL
AP 0387 SS	ND	ND	ND	ND	ND	53.60	7.60	21.00	28.60	17.80	SL

Auger: **AP0388 (Plot-6)**
 Described & sampled: Tshering Dorji & Kinley Penjor
 Survey area: Laya, Gasa
 Map unit:
 Soil Classification
 BSS Soil Series:
 Soil Taxonomy: ND
 WRB: ND
 Coordinates: 28° 03.0' 45.1" N and 89° 42' 28.3" E
 Topographic Map: No. 77H12, Scale 50000
 Location: Ca 1km NW of Taktshimakha or ca 1 km E of Laya village
 Altitude: 3512 masl
 Climate
 General: Alpine
 Recent Weather: Cloudy
 Parent material
 Solid: Thimphu, gneiss
 Drift: Colluvium
 Topography
 Landform: High Mountain
 Site position: Lower slope
 Aspect: S (177°)
 Slope: 38° (very steep), rectilinear
 Erosion: None
 Site drainage: Good
 Microrelief: < 25cm from undulations
 Surface
 Surface condition: Moist, slightly hard
 Surface cracks: None
 Surface capping: None
 Lichen/Algae: None
 Surface litter: Overall, raw decomposed mosses and grass about 2cm deep.
 Surface outcrops: Rare (1%), hard subangular gneiss & granite boulders
 Surface stone: None
 Land category: Government forest
 Landuse: Government forest
 Soil Depth Limit: Stone contact at 50 cm deep
 Soil Drainage Class: Well drained
 Notes / Comments: ND

Cm	Horizon Type	Description
0-15	Ah	Dark brown (10YR 3/3) moist; sandy loam with no mottles; few hard subangular medium quartzite & gneiss gravels; no concretions; moist & friable; non sticky and non plastic; no reaction to dilute HCl
15-50	B	Dark brown (10YR 4/3) moist; gravelly sandy loam with no mottles; common hard subangular coarse gneiss and quartzite gravels; no concretions; moist & slightly firm; non sticky and non plastic; no reaction to dilute HCl

SPAL analytical results for Auger AP0388 (Plot-6)

Survey area: Gasa / Lunana transect

Reaction, P, K & organic matter

SSU No.	Depth cm	Lab No	pH			EC mS/cm	Avail.P ppm	Avail.K ppm	OC %	Total N %	C:N
			H2O	KCl	Diff						
AP 0388 TS	0-20	35446	5.80	5.00	0.80	ND	4.00	122.26	4.80	0.30	16.02
AP 0388 SS	20-50	35447	5.62	4.45	1.17	ND	2.50	35.39	2.50	0.11	22.22

Exchangeable base status

SSU No.	Exchangeable (me/100g)				TEB	Extr Al	CEC		BS%	
	Ca	Mg	K	Na			AmOAc	ECEC	AmOAc	EBS%
AP 0388 TS	11.58	1.80	0.85	0.12	14.35	ND	19.87	ND	72	ND
AP 0388 SS	4.28	0.57	0.34	0.12	5.31	ND	10.03	ND	53	ND

Fine earth granulometric

SSU No.	Sand						Silt			Clay	Texture class
	>1000 micron	425- 1000	212- 425	106- 212	50-106	Total sand	20-50 micron	2-20	Total silt		
AP 0388 TS	ND	ND	ND	ND	ND	56.80	7.40	21.20	28.60	14.60	SL
AP 0388 SS	ND	ND	ND	ND	ND	57.00	7.60	18.00	25.60	17.40	SL

Auger: **AP0389 (Plot-7)**
 Described & sampled: Tshering Dorji & Kinley Penjor
 Survey area: Rodophu, Gasa
 Map unit:
 Soil Classification
 BSS Soil Series:
 Soil Taxonomy: ND
 WRB: ND
 Coordinates: 28° 02.0' 23.7" N and 89° 47' 28.4" E
 Topographic Map: No. 77H16, Scale 50000
 Location: Ca 150m away from the camp site
 Altitude: 4238 masl
 Climate
 General: Alpine
 Recent Weather: Cloudy
 Parent material
 Solid: Thimphu, gneiss
 Drift: Alluvium
 Topography
 Landform: Valley
 Site position: Flood plain
 Aspect: S (177°)
 Slope: 1° (level to nearly level), rectilinear
 Erosion: None
 Site drainage: Poor
 Microrelief: < 25cm from mound
 Surface
 Surface condition: Moist, slightly hard
 Surface cracks: None
 Surface capping: None
 Lichen/Algae: None
 Surface litter: Dense, raw decomposed mosses about 2 cm deep
 Surface outcrops: None
 Surface stone: Many
 Land category: Tsamdro
 Landuse: Tsamdro
 Soil Depth Limit: Stone contact at 30cm deep
 Soil Drainage Class: Somewhat excessively well drained
 Notes / Comments: ND

Cm	Horizon Type	Description
0-10	Ah	Very dark grayish brown (10YR 3/2) moist; fine sandy loam with no mottles; no stones; no concretions; moist & friable; non sticky and non plastic; no reaction to dilute HCl
10-30	Bw	Brown (10YR 5/3) moist; fine sand with common fine distinct reddish brown mottles; no stones; no concretions; moist & loose; non sticky and non plastic; no reaction to dilute HCl

SPAL analytical results for Auger AP0389 (Plot-7)

Survey area: Gasa / Lunana transect

Reaction, P, K & organic matter

SSU No.	Depth cm	Lab No	pH			EC mS/cm	Avail.P ppm	Avail.K ppm	OC %	Total N %	C:N
			H2O	KCl	Diff						
AP 0389 TS	0-20	35448	5.45	4.45	1.00	ND	12.32	45.58	0.80	0.14	5.69
AP 0389 SS	20-30	35449	5.41	4.60	0.81	ND	7.17	16.45	5.20	0.08	63.35

Exchangeable base status

SSU No.	Exchangeable (me/100g)				TEB	Extr Al	CEC		BS%	
	Ca	Mg	K	Na			AmOAc	ECEC	AmOAc	EBS%
AP 0389 TS	3.72	0.78	0.17	0.11	4.78	ND	7.21	ND	66	ND
AP 0389 SS	0.23	0.22	0.08	0.10	0.64	ND	0.45	ND	100	ND

Fine earth granulometric

SSU No.	Sand						Silt			Clay	Texture class
	>1000 micron	425-1000	212-425	106-212	50-106	Total sand	20-50 micron	2-20	Total silt		
AP 0389 TS	ND	ND	ND	ND	ND	67.90	14.30	13.80	28.10	4.00	SL
AP 0389 SS	ND	ND	ND	ND	ND	77.60	6.60	12.60	19.20	3.20	LS

Auger: **AP0390 (Plot-8)**
 Described & sampled: Tshering Dorji & Kinley Penjor
 Survey area: Above Rodophu, Gasa
 Map unit:
 Soil Classification
 BSS Soil Series:
 Soil Taxonomy: ND
 WRB: ND
 Coordinates: 28° 01.0' 23.9" N and 89° 48' 30.1" E
 Topographic Map: No. 77H16, Scale 50000
 Location: Ca 150m away from the camp site
 Altitude: 4786 masl
 Climate
 General: Alpine
 Recent Weather: Cloudy
 Parent material
 Solid: Thimphu, gneiss
 Drift: Glacial
 Topography
 Landform: Mountain
 Site position: Moraine
 Aspect: NW (308°)
 Slope: 7° (steep), concave
 Erosion: None
 Site drainage: Good
 Microrelief: 100-200cm from undulations
 Surface
 Surface condition: Wet, soft
 Surface cracks: None
 Surface capping: None
 Lichen/Algae: None
 Surface litter: Scattered, raw decomposed mosses about 2 cm deep
 Surface outcrops: Abundant hard subangular granite & gneiss boulders
 Surface stone: Many
 Land category: Wasteland
 Landuse: Wasteland
 Soil Depth Limit: Stone contact at 40cm deep
 Soil Drainage Class: Well drained
 Notes / Comments: ND

Cm	Horizon Type	Description
0-20	Ah	Black (10YR 2/1) moist; humic loam with no mottles; rare slightly hard subangular fine quartzite gravels; no concretions; moist & friable; non sticky and non plastic; no reaction to dilute HCl
20-40	Bw	Yellowish brown (10YR 5/4) moist; gravelly loamy sand with no mottles; many slightly hard subangular medium quartzite gravels; no concretions; moist & loose; non sticky and non plastic; no reaction to dilute HCl

SPAL analytical results for Auger AP0390 (Plot-8)

Survey area: Gasa / Lunana transect

Reaction, P, K & organic matter

SSU No.	Depth cm	Lab No	pH			EC mS/cm	Avail.P ppm	Avail.K ppm	OC %	Total N %	C:N
			H2O	KCl	Diff						
AP 0390 TS	0-20	35450	5.05	4.41	0.64	ND	4.33	15.78	7.30	0.41	18.00
AP 0390 SS	20-40	35451	5.35	4.80	0.55	ND	13.20	0.05	1.00	0.09	10.64

Exchangeable base status

SSU No.	Exchangeable (me/100g)				TEB	Extr Al	CEC		BS%	
	Ca	Mg	K	Na			AmOAc	ECEC	AmOAc	EBS%
AP 0390 TS	0.49	0.14	0.16	0.14	0.92	ND	1.76	ND	52	ND
AP 0390 SS	0.35	0.01	0.07	0.13	0.17	ND	10.37	ND	2	ND

Fine earth granulometric

SSU No.	Sand						Silt			Clay	Texture class
	>1000 micron	425-1000	212-425	106-212	50-106	Total sand	20-50 micron	2-20	Total silt		
AP 0390 TS	ND	ND	ND	ND	ND	65.20	9.10	18.50	27.60	7.20	SL
AP 0390 SS	ND	ND	ND	ND	ND	64.80	6.60	21.50	28.10	7.10	SL

Auger:	AP0391 (Plot-9)
Described & sampled:	Tshering Dorji & Kinley Penjor
Survey area:	Below Ganglakarchung, Gasa
Map unit:	
Soil Classification	
BSS Soil Series:	
Soil Taxonomy:	ND
WRB:	ND
Coordinates:	28° 04.0' 11.9" N and 89° 53' 38.7" E
Topographic Map:	No. 77H16, Scale 50000
Location:	Ca 3 hrs walk N of Narethang
Altitude:	4687 masl
Climate	
General:	Alpine
Recent Weather:	Cloudy
Parent material	
Solid:	Thimphu, gneiss
Drift:	Glacial
Topography	
Landform:	Mountain
Site position:	Moraine
Aspect:	N (10°)
Slope:	5° (moderately sloping), convex
Erosion:	None
Site drainage:	Good
Microrelief:	50-100cm from undulations
Surface	
Surface condition:	Wet, slightly hard
Surface cracks:	None
Surface capping:	None
Lichen/Algae:	None
Surface litter:	Overall, raw decomposed mosses about 2 cm deep
Surface outcrops:	Abundant hard subangular granite & gneiss boulders
Surface stone:	None
Land category:	Wasteland
Landuse:	Wasteland
Soil Depth Limit:	Stone contact at 25cm deep
Soil Drainage Class:	Well drained
Notes / Comments:	ND

Cm	Horizon Type	Description
0-10	Ah	Black (10YR 2/1) moist; humic loam with no mottles; rare slightly hard subangular fine quartzite gravels; no concretions; moist & friable; non sticky and non plastic; no reaction to dilute HCl
10-25	Bw	Dark yellowish brown (10YR 4/4) moist; gravelly loamy sand with no mottles; common slightly hard subangular fine quartzite gravels; no concretions; moist & loose; non sticky and non plastic; no reaction to dilute HCl

SPAL analytical results for Auger AP0391 (Plot-9)

Survey area: Gasa / Lunana transect

Reaction, P, K & organic matter

SSU No.	Depth cm	Lab No	pH			EC mS/cm	Avail.P ppm	Avail.K ppm	OC %	Total N %	C:N
			H2O	KCl	Diff						
AP 0391 TS	0-20	35452	5.02	4.23	0.79	ND	4.07	32.15	>15	0.62	ND
AP 0391 SS	20-25	35453	5.32	4.40	0.92	ND	6.22	13.00	3.40	0.10	33.24

Exchangeable base status

SSU No.	Exchangeable (me/100g)				TEB	Extr Al	CEC		BS%	
	Ca	Mg	K	Na			AmOAc	ECEC	AmOAc	EBS%
AP 0391 TS	9.47	0.50	0.17	0.15	10.30	ND	26.14	ND	39	ND
AP 0391 SS	0.34	0.13	0.11	0.17	0.07	ND	4.61	ND	2	ND

Fine earth granulometric

SSU No.	Sand						Silt			Clay	Texture class
	>1000 micron	425-1000	212-425	106-212	50-106	Total sand	20-50 micron	2-20	Total silt		
AP 0391 TS	ND	ND	ND	ND	ND	60.90	7.20	20.40	27.60	11.50	SL
AP 0391 SS	ND	ND	ND	ND	ND	76.10	4.40	12.50	16.90	7.00	SL

Auger:	AP0392 (Plot-10)
Described & sampled:	Tshering Dorji & Kinley Penjor
Survey area:	On the way to Wochi, Gasa
Map unit:	
Soil Classification	
BSS Soil Series:	
Soil Taxonomy:	ND
WRB:	ND
Coordinates:	28° 00.0' 59.4" N and 89° 58' 36.0" E
Topographic Map:	No. 77H16, Scale 50000
Location:	Ca 2 hrs walk towards Wochi
Altitude:	3656 masl
Climate	
General:	Sub-alpine
Recent Weather:	Cloudy
Parent material	
Solid:	Thimphu, gneiss
Drift:	Alluvium
Topography	
Landform:	Valley
Site position:	Flood plain
Aspect:	SSE (165°)
Slope:	12° (strongly sloping), rectilinear
Erosion:	Slight, splash and sheet
Site drainage:	Good
Microrelief:	50-100cm from undulations
Surface	
Surface condition:	Moist, hard
Surface cracks:	None
Surface capping:	None
Lichen/Algae:	None
Surface litter:	Scattered, raw decomposed mosses about 1 cm deep
Surface outcrops:	Abundant hard subangular granite boulders
Surface stone:	None
Land category:	Wasteland
Landuse:	Wasteland
Soil Depth Limit:	Stone contact at 25cm deep
Soil Drainage Class:	Well drained
Notes / Comments:	ND

Cm	Horizon Type	Description
0-10	Ah	Light brownish gray (2.5Y 6/2) moist; sand with no mottles; abundant slightly hard subangular quartzite gravels; no concretions; moist & loose; non sticky and non plastic; no reaction to dilute HCl

SPAL analytical results for Auger AP0392 (Plot-10)**Survey area: Gasa / Lunana transect**

Reaction, P, K & organic matter

SSU No.	Depth cm	SPAL Lab No	pH			EC mS/cm	Avail.P ppm	Avail.K ppm	OC %	Total N %	C:N
			H2O	KCl	Diff						
AP 0392 TS	0-10	35454	6.01	4.92	1.09	ND	6.14	5.51	0.50	0.13	3.79

Exchangeable base status

SSU No.	Exchangeable (me/100g)				TEB	Extr Al	CEC		BS%	
	Ca	Mg	K	Na			AmOAc	ECEC	AmOAc	EBS%
AP 0392 TS	0.02	0.04	0.10	0.21	0.33	ND	2.58	ND	13	ND

Fine earth granulometric

SSU No.	Sand						Silt			Clay	Texture class
	>1000 micron	425- 1000	212- 425	106- 212	50-106	Total sand	20-50 micron	2-20	Total silt		
AP 0392 TS	ND	ND	ND	ND	ND	96.60	0.00	1.60	1.60	1.80	S

Auger:	AP0393 (Plot-11)
Described & sampled:	Tshering Dorji & Kinley Penjor
Survey area:	Wochi, Gasa
Map unit:	
Soil Classification	
BSS Soil Series:	
Soil Taxonomy:	ND
WRB:	ND
Coordinates:	28° 00.0' 36.6" N and 89° 59' 46.5" E
Topographic Map:	No. 77H16, Scale 50000
Location:	Ca 50m NW of the campsite at Wochi
Altitude:	3942 masl
Climate	
General:	Sub alpine
Recent Weather:	Cloudy
Parent material	
Solid:	Thimphu, gneiss
Drift:	Colluvium
Topography	
Landform:	Mountain
Site position:	Mid slope
Aspect:	S (183°)
Slope:	17° (steep), rectilinear
Erosion:	None
Site drainage:	Good
Microrelief:	25-50cm from undulations
Surface	
Surface condition:	Wet, soft
Surface cracks:	None
Surface capping:	None
Lichen/Algae:	None
Surface litter:	Dense, raw decomposed mosses and leaves about 5cm deep
Surface outcrops:	Common hard subangular quartzite boulders
Surface stone:	None
Land category:	Government forest
Landuse:	Government forest
Soil Depth Limit:	No
Soil Drainage Class:	Well drained
Notes / Comments:	ND

Cm	Horizon Type	Description
0-15	Ah	Very dark brown (10YR 2/2) moist; humic loam with no mottles; no stones; no concretions; moist & friable; non sticky and non plastic; no reaction to dilute HCl
15-45	Bw	Brown (10YR 5/3) moist; fine sandy loam with no mottles; no stones; no concretions; moist & slightly firm; non sticky and non plastic; no reaction to dilute HCl
45-50	Bw1	Light olive gray (5Y 6/2) moist; fine sandy loam with no mottles; no stones; no concretions; moist & slightly firm; slightly sticky and non plastic; no reaction to dilute HCl
50-70	Bw2	Dark yellowish brown (10YR 4/6) moist; fine sandy loam with no mottles; no stones; no concretions; moist & slightly firm; slightly sticky and non plastic; no reaction to dilute HCl
70-100	Bw3	Light olive brown (2.5Y 5/3) moist; silty clay loam with no mottles; no stones; no concretions; moist & slightly firm; sticky and plastic; no reaction to dilute HCl

SPAL analytical results for Auger AP0393 (Plot-11)

Survey area: Gasa / Lunana transect

Reaction, P, K & organic matter

SSU No.	Depth cm	Lab No	pH			EC mS/cm	Avail.P ppm	Avail.K ppm	OC %	Total N %	C:N
			H2O	KCl	Diff						
AP 0393 TS	0-20	35455	4.18	3.35	0.83	ND	10.24	198.29	>15.00	0.08	ND
AP 0393 SS	20-100	35456	4.55	3.99	0.56	ND	2.77	39.20	6.30	0.34	18.30

Exchangeable base status

SSU No.	Exchangeable (me/100g)				TEB	Extr Al	CEC		BS%	
	Ca	Mg	K	Na			AmOAc	ECEC	AmOAc	EBS%
AP 0393 TS	ND	ND	0.00	0.00	ND	ND	0.00	ND	ND	ND
AP 0393 SS	0.18	0.41	0.22	0.24	0.68	ND	22.39	ND	3	ND

Fine earth granulometric

SSU No.	Sand						Silt			Clay	Texture class
	>1000 micron	425-1000	212-425	106-212	50-106	Total sand	20-50 micron	2-20	Total silt		
AP 0393 TS	ND	ND	ND	ND	ND	69.00	8.60	13.10	21.70	9.30	SL
AP 0393 SS	ND	ND	ND	ND	ND	38.90	13.90	31.60	45.50	15.60	L

Auger: **AP0394 (Plot-12)**
 Described & sampled: Tshering Dorji & Kinley Penjor
 Survey area: Lhedi, Gasa
 Map unit:
 Soil Classification
 BSS Soil Series:
 Soil Taxonomy: ND
 WRB: ND
 Coordinates: 28° 00.0' 26.0" N and 90° 03.0' 52.6" E
 Topographic Map: No. 77L04, Scale 50000
 Location: Ca 2 hrs walk from SW towards Lhedi
 Altitude: 3798 masl
 Climate
 General: Alpine
 Recent Weather: Cloudy
 Parent material
 Solid: Thimphu, gneiss
 Drift: Colluvium
 Topography
 Landform: Mountain
 Site position: Mid slope
 Aspect: ESE (113°)
 Slope: 28° (very steep), rectilinear
 Erosion: None
 Site drainage: Good
 Microrelief: < 25cm from undulations
 Surface
 Surface condition: Moist, soft
 Surface cracks: None
 Surface capping: None
 Lichen/Algae: None
 Surface litter: Overall, raw decomposed mosses & grass about 2cm deep
 Surface outcrops: Few hard subrounded granite boulders
 Surface stone: None
 Land category: Alpine meadow
 Landuse: Alpine meadow
 Soil Depth Limit: Gravels & stone contact at 55cm deep
 Soil Drainage Class: Well drained
 Notes / Comments: ND

Cm	Horizon Type	Description
0-15	Ah	Very dark brown (10YR 2/2) moist; loam with no mottles; no stones; no concretions; moist & friable; non sticky and non plastic; no reaction to dilute HCl
15-30	Bw	Dark yellowish brown (10YR 4/4) moist; sandy loam with no mottles; no stones; no concretions; moist & slightly friable; non sticky and non plastic; no reaction to dilute HCl
30-55	Bw1	Yellowish brown (10YR 5/8) moist; fine sandy clay loam with no mottles; no stones; no concretions; moist & slightly firm; slightly sticky and slightly plastic; no reaction to dilute HCl

SPAL analytical results for Auger AP0394 (Plot-12)

Survey area: Gasa / Lunana transect

Reaction, P, K & organic matter

SSU No.	Depth cm	Lab No	pH			EC mS/cm	Avail.P ppm	Avail.K ppm	OC %	Total N %	C:N
			H2O	KCl	Diff						
AP 0394 TS	0-20	35457	5.16	4.17	0.99	ND	2.71	50.18	9.00	0.58	15.54
AP 0394 SS	20-55	35458	5.62	4.63	0.99	ND	2.71	36.46	2.70	0.27	9.90

Exchangeable base status

SSU No.	Exchangeable (me/100g)				TEB	Extr Al	CEC		BS%	
	Ca	Mg	K	Na			AmOAc	ECEC	AmOAc	EBS%
AP 0394 TS	6.61	1.13	0.33	0.28	8.35	ND	19.53	ND	43	ND
AP 0394 SS	3.20	0.38	0.32	0.30	4.19	ND	10.91	ND	38	ND

Fine earth granulometric

SSU No.	Sand						Silt			Clay	Texture class
	>1000 micron	425- 1000	212- 425	106- 212	50-106	Total sand	20-50 micron	2-20	Total silt		
AP 0394 TS	ND	ND	ND	ND	ND	46.40	22.90	19.20	42.10	11.50	L
AP 0394 SS	ND	ND	ND	ND	ND	36.60	18.20	30.20	48.40	15.00	L

Auger: **AP0395 (Plot-13)**
 Described & sampled: Tshering Dorji & Kinley Penjor
 Survey area: Below Raptreng Tsho, Lunana/Gasa
 Map unit:
 Soil Classification
 BSS Soil Series:
 Soil Taxonomy: ND
 WRB: ND
 Coordinates: 28° 05.0' 49.4" N and 90° 14.0' 04.3" E
 Topographic Map: No. 77L04, Scale 50000
 Location: Ca 45 mins walk W of Thothormi tsho
 Altitude: 4333 masl
 Climate
 General: Alpine
 Recent Weather: Cloudy
 Parent material
 Solid: Thimphu, gneiss
 Drift: Glacial
 Topography
 Landform: Valley
 Site position: Lower slope
 Aspect: SSE (148°)
 Slope: 31° (very steep), convex
 Erosion: None
 Site drainage: Good
 Microrelief: < 25cm from undulations
 Surface
 Surface condition: Moist, slightly hard
 Surface cracks: None
 Surface capping: None
 Lichen/Algae: None
 Surface litter: Overall, raw decomposed mosses & leaves about 2cm deep
 Surface outcrops: Few hard subangular granite & gneiss boulders
 Surface stone: None
 Land category: Government forest
 Landuse: Government forest
 Soil Depth Limit: No
 Soil Drainage Class: Well drained
 Notes / Comments: ND

Cm	Horizon Type	Description
0-10	Ah	Dark grayish brown (10YR 4/2) moist; sandy loam with no mottles; no stones; no concretions; moist & slightly firm; non sticky and non plastic; no reaction to dilute HCl
10-20	Bw	Black (10YR 2/1) moist; humic loam with no mottles; no stones; no concretions; moist & slightly firm; non sticky and non plastic; no reaction to dilute HCl
20-30	Bw1	Dark brown (10YR 3/3) moist; sandy loam with no mottles; no stones; no concretions; moist & slightly firm; non sticky and non plastic; no reaction to dilute HCl
30-50	Bw2	Dark yellowish brown (10YR 3/4) moist; gravelly sandy loam with no mottles; few hard flat medium gneiss gravels; no concretions; moist & slightly firm; non sticky and non plastic; no reaction to dilute HCl

SPAL analytical results for Auger AP0395 (Plot-13)

Survey area: Gasa / Lunana transect

Reaction, P, K & organic matter

SSU No.	Depth cm	Lab No	pH			EC mS/cm	Avail.P ppm	Avail.K ppm	OC %	Total N %	C:N
			H2O	KCl	Diff						
AP 0395 TS	0-20	35459	5.22	4.32	0.90	ND	2.50	29.94	4.50	0.40	11.39
AP 0395 SS	20-50	35460	5.10	4.33	0.77	ND	2.67	12.34	4.40	0.11	39.10

Exchangeable base status

SSU No.	Exchangeable (me/100g)				TEB	Extr Al	CEC		BS%	
	Ca	Mg	K	Na			AmOAc	ECEC	AmOAc	EBS%
AP 0395 TS	2.84	0.39	0.22	0.30	3.75	ND	10.12	ND	37	ND
AP 0395 SS	0.48	0.10	0.10	0.29	0.97	ND	11.42	ND	9	ND

Fine earth granulometric

SSU No.	Sand						Silt			Clay	Texture class
	>1000 micron	425- 1000	212- 425	106- 212	50-106	Total sand	20-50 micron	2-20	Total silt		
AP 0395 TS	ND	ND	ND	ND	ND	38.90	17.90	30.70	48.60	12.50	L
AP 0395 SS	ND	ND	ND	ND	ND	436.0	14.10	33.00	47.10	9.30	L

Auger: **AP0396 (Plot-14)**
 Described & sampled: Tshering Dorji & Kinley Penjor
 Survey area: Choeju, Lunana/Gasa
 Map unit:
 Soil Classification
 BSS Soil Series:
 Soil Taxonomy: ND
 WRB: ND
 Coordinates: 28° 03.0' 58.9" N and 90° 09.0' 53.0" E
 Topographic Map: No. 77L04, Scale 50000
 Location: Ca 300m N of Choeju Lhakhang
 Altitude: 4140 masl
 Climate
 General: Alpine
 Recent Weather: Cloudy
 Parent material
 Solid: Thimphu, gneiss
 Drift: Colluvium
 Topography
 Landform: Mountain
 Site position: Lower slope
 Aspect: S (183°)
 Slope: 27° (very steep), rectilinear
 Erosion: Slight, splash & sheet
 Site drainage: Good
 Microrelief: < 25cm from undulations
 Surface
 Surface condition: Moist, moderately hard
 Surface cracks: None
 Surface capping: None
 Lichen/Algae: None
 Surface litter: Scattered, raw decomposed grass about 1cm deep
 Surface outcrops: None
 Surface stone: Rare hard subangular fine gneiss stones
 Land category: Government forest
 Landuse: Government forest
 Soil Depth Limit: No
 Soil Drainage Class: Well drained
 Notes / Comments: ND

Cm	Horizon Type	Description
0-30	Ah	Dark brown (10YR 3/3) moist; humic loam with no mottles; no stones; no concretions; moist & slightly friable; non sticky and non plastic; no reaction to dilute HCl
30-40	Bw	Dark yellowish brown (10YR 4/6) moist; silty loam with no mottles; no stones; no concretions; moist & slightly friable; slightly sticky and non plastic; no reaction to dilute HCl
40-60	Bw1	Dark yellowish brown (10YR 4/4) moist; fine silty loam with no mottles; no stones; no concretions; moist & slightly firm; slightly sticky and non plastic; no reaction to dilute HCl
60-100	Bw2	Yellowish brown (10YR 5/4) moist; fine sandy clay loam with no mottles; no stones; no concretions; moist & slightly firm; slightly sticky and slightly plastic; no reaction to dilute HCl

SPAL analytical results for Auger AP0396 (Plot-14)

Survey area: Laya / Lunana transect

Reaction, P, K & organic matter

SSU No.	Depth cm	Lab No	pH			EC mS/cm	Avail.P ppm	Avail.K ppm	OC %	Total N %	C:N
			H2O	KCl	Diff						
AP 0396 TS	0-20	35461	5.46	4.62	0.84	ND	2.44	59.47	4.90	0.16	31.32
AP 0396 SS	20-100	35462	5.67	4.74	0.93	ND	2.47	28.48	3.20	0.14	22.23

Exchangeable base status

SSU No.	Exchangeable (me/100g)				TEB	Extr Al	CEC		BS%	
	Ca	Mg	K	Na			AmOAc	ECEC	AmOAc	EBS%
AP 0396 TS	5.97	6.33	0.29	0.32	12.91	ND	10.52	ND	100	ND
AP 0396 SS	3.72	0.37	0.17	0.33	4.60	ND	13.06	ND	35	ND

Fine earth granulometric

SSU No.	Sand						Silt			Clay	Texture class
	>1000 micron	425- 1000	212- 425	106- 212	50-106	Total sand	20-50 micron	2-20	Total silt		
AP 0396 TS	ND	ND	ND	ND	ND	35.10	28.80	23.70	52.50	12.40	ZL
AP 0396 SS	ND	ND	ND	ND	ND	27.50	21.30	22.10	43.40	29.10	CL

ANNEX - 2 PLANT SPECIES IN DIFFERENT PLOTS

SI #	PLOT - 1		PLOT - 2	
	Species	Family	Species	Family
1	<i>Juniperus recurva</i>	Cupressaceae	<i>Abies densa</i>	Pinaceae
2	<i>Berberis aristata</i>	Berberidaceae	<i>Juniperus recurva</i>	Cupressaceae
3	<i>Elaeagnus parvifolia</i>	Elaeagnaceae	<i>Acer caudatum</i>	Aceraceae
4	<i>Hypericum choisianum</i>	Hypericaceae	<i>Viburnum nervosum</i>	Sambucaceae
5	<i>Pteridium revolutum</i>	Dennstaedtiaceae	<i>Pentapanax fragrans</i>	Araliaceae
6	<i>Aster neoelegans</i>	Asteraceae	<i>Rhododendron falconeri</i>	Ericaceae
7	<i>Osbeckia capitata</i>	Melastomataceae	<i>Sorbus microphylla</i>	Rosaceae
8	<i>Anaphalis sp.</i>	Asteraceae	<i>Rosa sericea</i>	Rosaceae
9	<i>Plantago erosa</i>	Plantaginaceae	<i>Cotoneaster microphyllus</i>	Rosaceae
10	<i>Artemisia indica</i>	Asteraceae	<i>Diplazium sp.</i>	Woodsiaceae
11	<i>Persicaria sp.</i>	Polygonaceae	<i>Ribes glaciale</i>	Grossulariaceae
12	<i>Primula denticulata</i>	Primulaceae	<i>Clintonia udensis</i>	Liliaceae
13	<i>Potentilla cuneata</i>	Rosaceae	<i>Elastotema sp.</i>	Urticaceae
14	<i>Hemiphragma heterophyllum</i>	Scrophulariaceae	<i>Oxalis corniculata</i>	Oxalidaceae
15	<i>Poa annua</i>	Poaceae	<i>Senecio sp.</i>	Asteraceae
16	<i>Rubus fragarioides</i>	Rosaceae	<i>Smilacina oleracea</i>	Liliaceae
17	<i>Bupleurum candollei</i>	Umbelliferae	<i>Streptopus simplex</i>	Liliaceae
18	<i>Drosera peltata</i>	Droseraceae	<i>Poa annua</i>	Poaceae
19	<i>Selaginella sp.</i>	Selaginellaceae	<i>Polygonatum multiflorum</i>	Liliaceae
20	<i>Nepeta lamiopsis</i>	Labiataeae	<i>Arisaema sp.</i>	Araliaceae
21	<i>Ligularia amplexicaulis</i>	Asteraceae	<i>Fragraria nubicola</i>	Rosaceae
22	<i>Galium sp.</i>	Rubiaceae	<i>Viola biflora</i>	Violaceae
23	<i>Daphne bholua</i>	Thymelaeaceae	<i>Smilax ovalifolia</i>	Smilacaceae
24	<i>Jasminum humile</i>	Oleaceae	<i>Impatiens gammei</i>	Balsaminaceae
25	<i>Thalictrum reniforme</i>	Ranunculaceae	<i>Rhododendron barbatum</i>	Ericaceae
26	<i>Ribes laciniatum</i>	Grossulariaceae		
27	<i>Hypericum sp.</i>	Hypericaceae		
28	<i>Astragalus sp.</i>	Leguminosae		
29	<i>Cyanotis vagna</i>	Commelinaceae		
30	<i>Senecio sp.</i>	Asteraceae		
31	<i>Pterocephalus hookeri</i>	Dipsacaceae		
32	<i>Carex sp.</i>	Poaceae		

SI #	PLOT - 3		PLOT - 4	
	Species	Family	Species	Family
1	<i>Abies densa</i>	Pinaceae	<i>Picea spinulosa</i>	Pinaceae
2	<i>Betula utilis</i>	Betulaceae	<i>Juniperus squamata</i>	Cupressaceae
3	<i>Rhododendron arboreum</i>	Ericaceae	<i>Prunus rufa</i>	Rosaceae
4	<i>Daphne bolua</i>	Thymelaeaceae	<i>Salix sikkimensis</i>	Salicaceae
5	<i>Berberis aristata</i>	Berberidaceae	<i>Ribes alpestre</i>	Grossulariaceae
6	<i>Sarcococa hookeriana</i>	Buxaceae	<i>Rosa Sericea</i>	Rosaceae
7	<i>Maddenia himalaica</i>	Rosaceae	<i>Ribes Laciniatum</i>	Grossulariaceae
8	<i>Acer caudatum</i>	Aceraceae	<i>Heracleum obtusifolium</i>	Umbelliferae
9	<i>Yushania yadongensis</i>	Poaceae	<i>Thalictrum reniforme</i>	Ranunculaceae
10	<i>Senecio sp.</i>	Asteraceae	<i>Senecio sp.</i>	Asteraceae
11	<i>Dryopteris sp.</i>	Dryopteridaceae	<i>Aralia cachemirica</i>	Araliaceae
12	<i>Paris polyphylla</i>	Liliaceae	<i>Viola biflora</i>	Violaceae
13	<i>Elastotema pusillum</i>	Urticaceae	<i>Selinum sp.</i>	Umbelliferae
14	<i>Fragraria nubicola</i>	Rosaceae	<i>Saxifraga sp.</i>	Saxifragaceae
15	<i>Impatiens sulcata</i>	Balsaminaceae	<i>Lepisorus sp.</i>	Polypodiaceae
16	<i>Viola biflora</i>	Violaceae	<i>Chaerophyllum villosum</i>	Umbelliferae
17	<i>Pyrola corbieri</i>	Pyrolaceae	<i>Hemiphragma heterophylla</i>	Scrophulariaceae
18	<i>Pternopetalum radiatum</i>	Umbelliferae	<i>Fragraria nubicola</i>	Rosaceae
19	<i>Lindera heterophylla</i>	Lauraceae	<i>Rosa macrophylla</i>	Rosaceae
20	<i>Habenaria arietina</i>	Orchidaceae	<i>Hydrangea heteromalla</i>	Hydrangeaceae
21	<i>Lepisorus sp.</i>	Polypodiaceae	<i>Aster sp.</i>	Asteraceae
22	<i>Epilobium wallichianum</i>	Onagraceae	<i>Helenia elliptica</i>	Gentianaceae
23	<i>Rubia wallichiana</i>	Rubiaceae	<i>Panax pseudo-ginseng</i>	Araliaceae
24	<i>Rosa sericea</i>	Rosaceae	<i>Berberis griffithiana</i>	Berberidaceae
25	<i>Persicaria runcinata</i>	Polygonaceae	<i>Cimicifuga foetida</i>	Ranunculaceae

	PLOT - 5		PLOT - 6	
SI #	Species	Family	Species	Family
1	<i>Juniperus pseudosabina</i>	Cupressaceae	<i>Picea spinulosa</i>	Pinaceae
2	<i>Juniperus squamata</i>	Cupressaceae	<i>Juniperus squamata</i>	Cupressaceae
3	<i>Cotoneaster microphylla</i>	Rosaceae	<i>Rosa macrophylla</i>	Rosaceae
4	<i>Thermopsis barbata</i>	Leguminosae	<i>Elsholtzia fruticosa</i>	Labiatae
5	<i>Cyananthus incanus</i>	Campanulaceae	<i>Pteridium revolutum</i>	Dennstaedtiaceae
6	<i>Bistorta affinis</i>	Polygonaceae	<i>Cotoneaster microphylla</i>	Rosaceae
7	<i>Onosma hookeri</i>	Boraginaceae	<i>Helenia elliptica</i>	Ranunculaceae
8	<i>Primula primulina</i>	Primulaceae	<i>Anemone rivularis</i>	Ranunculaceae
9	<i>Poa sp.</i>	Poaceae	<i>Iris clarkei</i>	Iridaceae
10	<i>Carex sp.</i>	Poaceae	<i>Campanula pallida</i>	Campanulaceae
11	<i>Salix sp.</i>	Salicaceae	<i>Drosera peltata</i>	Droseraceae
12	<i>Leontopodium himalayanum</i>	Asteraceae	<i>Cheilanthes sp.</i>	Pteridaceae
13	<i>Anaphalis busua</i>	Asteraceae	<i>Jasminum sp.</i>	Oleaceae
14	<i>Pterocephalodes hookeri</i>	Dipsacaceae	<i>Potentilla plurijuga</i>	Rosaceae
15	<i>Halenia elliptica</i>	Gentianaceae	<i>Pseudonaphalium hypoleucum</i>	Asteraceae
16	<i>Taraxacum cf. apargiiforme</i>	Asteraceae	<i>Satyrium nepalense</i>	Orchidaceae
17	<i>Lomatogonium himalayense</i>	Gentianaceae	<i>Saxifraga brachypoda</i>	Saxifragaceae
18	<i>Bhutanthera himalayana</i>	Orchidaceae	<i>Heracleum obtusifolium</i>	Umbelliferae
19	<i>Saussurea atkinsonii</i>	Asteraceae	<i>Clematis montana</i>	Ranunculaceae
20	<i>Rhododendron setosum</i>	Ericaceae	<i>Bupleurum candollei</i>	Umbelliferae
21	<i>Potentilla plurijuga</i>	Rosaceae	<i>Nepeta lamiopsis</i>	Labiatae
22	<i>Geranium nakaoanum</i>	Geraniaceae	<i>Plantago depressa</i>	Plantaginaceae
23	<i>Potentilla microphylla</i>	Rosaceae	<i>Pedicularis elwesii</i>	Scrophulariaceae
24	<i>Potentilla coriandrifolia</i>	Rosaceae	<i>Poa sp.</i>	Poaceae
25	<i>Potentilla bhutanica</i>	Rosaceae	<i>Carex sp.</i>	Poaceae
26	<i>Mazus sp.</i>	Scrophulariaceae	<i>Pterocephalodes hookeri</i>	Dipsacaceae
27			<i>Persecaria runcinata</i>	Polygonaceae
28			<i>Saxifraga sp.</i>	Saxifragaceae
29			<i>Artemisia indica</i>	Asteraceae
30			<i>Aster sp.</i>	Asteraceae
31			<i>Thalictrum reniforme</i>	Ranunculaceae
32			<i>Roscoea alpina</i>	Zingiberaceae
33			<i>Fagopyrum gracilipes</i>	Polygonaceae
34			<i>Sonchus sp.</i>	Asteraceae
35			<i>Streptopus sp.</i>	Liliaceae
36			<i>Geranium pratense</i>	Geraniaceae
37			<i>Gentiana sp.</i>	Gentianaceae
38			<i>Salvia scutellaria</i>	Labiatae
39			<i>Sophora</i>	Leguminosae
40			<i>Anaphalis busua</i>	Asteraceae
41			<i>Pedicularis megalantha</i>	Scrophulariaceae

	PLOT - 7		PLOT - 8	
Sl #	Species	Family	Species	Family
1	<i>Juniperus squamata</i>	Cupressaceae	<i>Rheum nobile</i>	Polygonaceae
2	<i>Rhododendron aeruginosum</i>	Ericaceae	<i>Rhododendron nivale</i>	Ericaceae
3	<i>Rhododendron anthopogon</i>	Ericaceae	<i>Bistorta affinis</i>	Polygonaceae
4	<i>Rhododendron nivale</i>	Ericaceae	<i>Saussurea gossipiphora</i>	Asteraceae
5	<i>Cassiope fastigata</i>	Ericaceae	<i>Rheum australe</i>	Polygonaceae
6	<i>Hippuris vulgaris</i>	Hippuridaceae	<i>Anaphalis triplinervis</i>	Asteraceae
7	<i>Selinum candollei</i>	Umbelliferae	<i>Poa sp.</i>	Poaceae
8	<i>Saxifraga brunonis</i>	Saxifragaceae	<i>Carex sp.</i>	Poaceae
9	<i>Carex sp.</i>	Poaceae	<i>Potentilla coriandifolia</i>	Rosaceae
10	<i>Poa sp.</i>	poaceae	<i>Lomatogonium himalayense</i>	Gentianaceae
11	<i>Potentilla coriandifolia</i>	Rosaceae	<i>Saxifraga brunonis</i>	Saxifragaceae
12	<i>Potentilla cuneata</i>	Rosaceae	<i>Selinum candollei</i>	Umbelliferae
13	<i>Oreorchis foliosa</i>	Orchidaceae	<i>Rhodiola himalayansis</i>	Saxifragaceae
14	<i>Primula primulina</i>	Primulaceae	<i>Gentiana elwesii</i>	Gentianaceae
15	<i>Anaphalis triplinervis</i>	Asteraceae		
16	<i>Potentilla microphylla</i>	Rosaceae		
17	<i>Bistorta affinis</i>	Polygonaceae		
18	<i>Gentiana elwesia</i>	gentianaceae		
19	<i>Pedicularis siphonanthae</i>	Scrophulariaceae		

SI #	PLOT - 9		PLOT - 10	
	Species	Family	Species	Family
1	<i>Rhododendron aeruginosum</i>	Ericaceae	<i>Abies densa</i>	Pinaceae
2	<i>Rhododendron anthopogon</i>	Ericaceae	<i>Larix griffithiana</i>	Pinaceae
3	<i>Rhododendron nivale</i>	Ericaceae	<i>Salix myrtilleacea</i>	Salicaceae
4	<i>Cassiope fastigata</i>	Ericaceae	<i>Rhododendron camelliiflorum</i>	Ericaceae
5	<i>Bergenia ciliata</i>	Saxifragaceae	<i>Anaphalis busua</i>	Asteraceae
6	<i>Pedicularis megalantha</i>	Scrophulariaceae	<i>Drynaria sp.</i>	Polypodiaceae
7	<i>Bistorta affinis</i>	Polygonaceae	<i>Sorbus microphylla</i>	Rosaceae
8	<i>Geranium pratense</i>	Geraniaceae	<i>Betula utilis</i>	Betulaceae
9	<i>Salix flabellaris</i>	Salicaceae	<i>Aster diplostephioides</i>	Asteraceae
10	<i>Anaphalis triplinervis</i>	Asteraceae	<i>Epilobium conspersum</i>	Onagraceae
11	<i>Saussurea gossipiphora</i>	Asteraceae	<i>Satyrium nepalense</i>	Orchidaceae
12	<i>Carex sp.</i>	Poaceae	<i>Fragaria nubicola</i>	Rosaceae
13	<i>Poa sp.</i>	Poaceae	<i>Potentilla coriandifolia</i>	Rosaceae
14	<i>Primula gracilipes</i>	Primulaceae	<i>Lepisorus sp.</i>	Polypodiaceae
15	<i>Primula minutissima</i>	Primulaceae	<i>Gaultheria trichophylla</i>	Ericaceae
16	<i>Leontopodium sp.</i>	Asteraceae	<i>Ribes sp.</i>	Grossulariaceae
17	<i>Rhodiola himalensis</i>	Saxifragaceae	<i>Aconogonon molle</i>	Polygonaceae
18	<i>Saussurea obvallata</i>	Asteraceae	<i>Rhododendron cinnabarinum</i>	Ericaceae
19	<i>Neopicrorhiza scrophulariiflora</i>	Scrophulariaceae	<i>Duchesnea indica</i>	Rosaceae
20			<i>Hippuris vulgaris</i>	Hippuridaceae
21			<i>Rhododendron lepidotum</i>	Ericaceae
22			<i>Carex sp.</i>	Poaceae
23			<i>Poa sp.</i>	Poaceae
24			<i>Rhodiola bupleuroides</i>	Saxifragaceae
25			<i>Rhododendron thomsonii</i>	Ericaceae
26			<i>Selinum candollei</i>	Umbelliferae
27			<i>Rhododendron lanatum</i>	Ericaceae
28			<i>Lonicera tomentella</i>	Caprifoliaceae

	PLOT - 11		PLOT - 12	
SI #	Species	Family	Species	Family
1	<i>Juniperus squamata</i>	Cupressaceae	<i>Juniperus squamata</i>	Cupressaceae
2	<i>Salix myrtillicae</i>	Salicaceae	<i>Salix myrtillicae</i>	Salicaceae
3	<i>Rhododendron lepidotum</i>	Ericaceae	<i>Rhododendron lepidotum</i>	Ericaceae
4	<i>Berberis griffithiana</i>	Berberidaceae	<i>Iris clarkei</i>	Iridaceae
5	<i>Cotoneaster simonsii</i>	Rosaceae	<i>Cotoneaster macrophylla</i>	Rosaceae
6	<i>Cyananthus lobatus</i>	Campanulaceae	<i>Anaphalis busua</i>	Asteraceae
7	<i>Potentilla microphylla</i>	Rosaceae	<i>Bupleurum candollei</i>	Umbelliferae
8	<i>Bistorta affinis</i>	Polygonaceae	<i>Aster diploslephioides</i>	Asteraceae
9	<i>Geranium sp.</i>	Geraniaceae	<i>Thermopsis barbata</i>	Leguminosae
10	<i>Senecio raphanifolius</i>	Asteraceae	<i>Pterocephalodes hookeri</i>	Dipsacaceae
11	<i>Aconogonum molle</i>	Polygonaceae	<i>Satyrium nepalense</i>	Orchidaceae
12	<i>Strobilanthes sp.</i>	Acanthaceae	<i>Hemimum lanceum</i>	Orchidaceae
13	<i>Bergenia ciliata</i>	Saxifragaceae	<i>Acanthocalyx nepalensis</i>	Dipsacaceae
14	<i>Thalictrum reniforme</i>	Ranunculaceae	<i>Saxifraga sp.</i>	Saxifragaceae
15	<i>Polygonatum cirrhifolium</i>	Liliaceae	<i>Serratula pallida</i>	Asteraceae
16	<i>Aconitum spicatum</i>	Ranunculaceae	<i>Cyananthus lobatus</i>	Camapanulaceae
17	<i>Heracleum wallichii</i>	Umbelliferae	<i>Potentilla coriandifolia</i>	Rosaceae
18	<i>Rosa sericea</i>	Rosaceae	<i>Potentilla anserina</i>	Rosaceae
19	<i>Rhododendron cinnabarinum</i>	Ericaceae	<i>Selinum candollei</i>	Umbelliferae
20	<i>Lepisorus sp.</i>	Polypodiaceae	<i>Heracleum wallichii</i>	Umbelliferae
21	<i>Juncus himalensis</i>	Juncaceae	<i>Onosma hookerii</i>	Boraginaceae
22	<i>Acanthocalyx nepalensis</i>	Dipsacaceae	<i>Geranium himalayense</i>	Geraniaceae
23	<i>Streptopus sp.</i>	Liliaceae	<i>Androcerys pugioniformis</i>	Orchidaceae
24	<i>Saxifraga parnassifolia</i>	Saxifragaceae	<i>Poa sp.</i>	Poaceae
25	<i>Elsholtzia strobilifera</i>	Asteraceae	<i>Carex sp.</i>	Poaceae
26	<i>Pedicularis megalantha</i>	Scrophulariaceae	<i>Geum elatum</i>	Rosaceae
27	<i>Anaphalis busua</i>	Asteraceae	<i>Pedicularis sp.</i>	Scrophulariaceae
28	<i>Lonicera sp.</i>	Caprifoliaceae	<i>Saxifraga brachypoda</i>	Saxifragaceae
29	<i>Arisaema jacquemontii</i>	Araliaceae	<i>Cheilanthes sp.</i>	Pteridaceae
30	<i>Pilea sp.</i>	Urticaceae	<i>Anemone rivularis</i>	Ranunculaceae
31	<i>Geum elatum</i>	Rosaceae	<i>Ligularia amplexicaulis</i>	Asteraceae
32	<i>Leucas ciliata</i>	Labiatae	<i>polygonatum cirrhosum</i>	Liliaceae
33	<i>Nepeta lamiopsis</i>	Labiatae	<i>Persicaria nepalensis</i>	Polygonaceae
34	<i>Persicaria runcinata</i>	Polygonaceae	<i>Notholirion bulbiferum</i>	Liliaceae
35	<i>Poa sp.</i>	Poaceae	<i>Leonthopodium himalayanum</i>	Asteraceae
36	<i>Impatiens arguata</i>	Balsaminaceae	<i>Cyananthus incanus</i>	Camapanulaceae
37	<i>Cardamine violacea</i>	Cruciferae	<i>Ephedra gerardiana</i>	Ephedraceae
38	<i>Gaultheria trichophylla</i>	Ericaceae	<i>Lomatogonium carinthiacum</i>	Gentianaceae
39	<i>Selinum candollei</i>	Umbelliferae	<i>Gentianella sp.</i>	Gentianaceae
40	<i>Rhododendron thomsonii</i>	Ericaceae		
41	<i>Rhododendron wightii</i>	Ericaceae		
42	<i>Hypericum monanthemum</i>	Hypericaceae		

	PLOT - 13		PLOT - 14	
Sl #	Species	Family	Species	Family
1	<i>Juniperus squamata</i>	Cupressaceae	<i>Juniperus squamata</i>	Cupressaceae
2	<i>Rhododendron lepidotum</i>	Ericaceae	<i>Rhododendron lepidotum</i>	Ericaceae
3	<i>Berberis griffithiana</i>	Berberidaceae	<i>Iris clarkei</i>	Iridaceae
4	<i>Ligularia amplexicaulis</i>	Asteraceae	<i>Onosma hookeri</i>	Boraginaceae
5	<i>Anemone rivularis</i>	Ranunculaceae	<i>Nardostachys hookeri</i>	Valerianaceae
6	<i>Thermopsis barbata</i>	Leguminosae	<i>Cotoneaster microphylla</i>	Rosaceae
7	<i>Aster diploslephoides</i>	Asteraceae	<i>Potentilla microphylla</i>	Rosaceae
8	<i>Pedicularis siphonanthae</i>	Scrophulariaceae	<i>Leonthopodium sp.</i>	Asteraceae
9	<i>polygonatum cirrhifolium</i>	Liliaceae	<i>Anaphalis busua</i>	Asteraceae
10	<i>Thalictrum reniforme</i>	Ranunculaceae	<i>Plantago erosa</i>	Plantaginaceae
11	<i>Halenia elliptica</i>	Gentianaceae	<i>Juncus sp.</i>	Juncaceae
12	<i>Cyananthus incanus</i>	Campanulaceae	<i>Festuca boriana</i>	Poaceae
13	<i>Saxifraga parnassifolia</i>	Saxifragaceae	<i>Lomatogonium carinthicum</i>	Gentianaceae
14	<i>Potentilla microphylla</i>	Rosaceae	<i>Pedicularis megalantha</i>	Scrophulariaceae
15	<i>Festuca boriana</i>	Poaceae	<i>Sunipia brachypoda</i>	Orchidaceae
16	<i>Geranium himalayense</i>	Geraniaceae	<i>Potentilla anserina</i>	Rosaceae
17	<i>Acanthocalyx nepalense</i>	Dipsacaceae	<i>Persicaria nepalensis</i>	Polygonaceae
18	<i>Cotoneaster simsonii</i>	Rosaceae	<i>Serratula pallida</i>	Asteraceae
19	<i>Rhodiola bupleuroides</i>	Saxifragaceae	<i>Poa sp.</i>	Poaceae
20	<i>Potentilla fruticosa</i>	Rosaceae	<i>Arisaema sp.</i>	Liliaceae
21	<i>Onosma hookeri</i>	Boraginaceae	<i>Anemone rivularis</i>	Ranunculaceae
22	<i>Cremanthodium sp.</i>	Asteraceae	<i>Aster diplostephioides</i>	Asteraceae
23	<i>Allium wallichii</i>	Liliaceae	<i>Aconitum spicatum</i>	Ranunculaceae
24	<i>Poa sp.</i>	Poaceae	<i>Cyananthus incanus</i>	Campanulaceae
25	<i>Dubyaea hispida</i>	Asteraceae	<i>Rhodiola bupleuroides</i>	Saxifragaceae
26	<i>Persicaria nepalensis</i>	Polygonaceae	<i>Androcerys pugioniformis</i>	Orchidaceae
27	<i>Saxifraga brachypoda</i>	Saxifragaceae	<i>Gymnadenia orchidis</i>	Orchidaceae
28	<i>Ephedra gerardinia</i>	Ephedraceae	<i>Silene edgeworthii</i>	Caryophyllaceae
29	<i>Sedum sp.</i>	Saxifragaceae	<i>Pilea sp.</i>	Urticaceae
30	<i>Geum elatum</i>	Rosaceae	<i>Astragalus sp.</i>	Leguminosae
31	<i>Anaphalis busua</i>	Asteraceae		
32	<i>Iris clarkei</i>	Iridaceae		
33	<i>Bistorta affinis</i>	Polygonaceae		
34	<i>Gymnadenia orchidis</i>	Orchidaceae		
35	<i>Nannoglottis hookeri</i>	Asteraceae		
36	<i>Pilea sp.</i>	Urticaceae		
37	<i>Silene edgeworthii</i>	Caryophyllaceae		
38	<i>Chaerophyllum villosum</i>	Umbelliferae		
39	<i>Prangos pabularia</i>	Umbelliferae		
40	<i>Inula hookeri</i>	Asteraceae		